

# ECOLOGICAL STUDIES IN SARISKA TIGER RESERVE, RAJASTHAN

FINAL REPORT

2009



भारतीय वन्यजीव संस्थान  
Wildlife Institute of India

# Ecological Studies In Sariska Tiger Reserve, Rajasthan



भारतीय वन्यजीव संस्थान  
Wildlife Institute of India

2009

# Ecological Studies In Sariska Tiger Reserve, Rajasthan

## THE TEAM

ADVISOR : Sh. P.R. SINHA

INVESTIGATORS : Dr. K. SANKAR  
Sh. QAMAR QURESHI

RESERCHERS : KRISHNENDU MONDAL  
DARSH WORAH  
TANUSHREE SRIVASTAVA

TECHNICAL INPUTS : SANTANU BASU  
SHILPI GUPTA  
VINOD THAKUR

### *Citation*

---

Sankar K., Qamar Qureshi, Krishnendu Mondal, D. Worah, T. Srivastava, S. Gupta and S. Basu. 2009. Ecological studies in Sariska Tiger Reserve, Rajasthan. Final Report. Wildlife Institute of India, Dehra Dun. 145 Pp.

# Contents

---

	Page Number
ACKNOWLEDGMENT	
1 INTRODUCTION	1
OBJECTIVES	3
2 VEGETATION AND LAND COVER OF SARISKA TIGER RESERVE (STR)	4
2.1. Introduction	4
2.2. Methodology	6
2.2.1. Data Source	6
2.3 Data Processing and Analysis	6
2.3.1. Satellite data	6
2.3.2. Survey of India toposheet	7
2.3.3. Vegetation and land cover mapping	7
2.3.4. Park infrastructure mapping	7
2.4. Results and interpretation of maps.	8
2.4.1. General maps	8
2.4.2. False Color Composite (FCC) of Sariska Tiger Reserve	13
3 STATUS AND DISTRIBUTION OF PREY SPECIES	30
3.1. Introduction	30
3.2. Methodology	31
3.3. Results and discussion	33
3.3.1. Density estimation of prey species	33
3.3.2. Estimation of density of prey species in Sariska Range of STR	36
3.3.3. Estimation of density of prey species in Akbarpur Range of STR	37

3.3.4.	Estimation of density of prey species in Tehla Range of STR	38
3.3.5.	Estimation of density of prey species in Talvriksh Range of STR	39
3.3.6.	Comparison of prey densities with other studies (1991 to 2007) in STR	41
4	STATUS AND DISTRIBUTION OF LEOPARD AND OTHER CARNIVORES	52
4.1.	Introduction	52
4.2.	Methodology	52
4.3.	Results and discussion	55
4.3.1.	Estimation of effective trapping area	57
4.3.2.	Estimation of leopard population in the study area	59
4.3.3.	Estimation of leopard density in the effective trapping area	59
4.3.4.	Past studies in Sariska on leopard	60
4.3.5.	Comparison of leopard density with other studies	61
4.3.6.	Comparison of wild ungulate encounter rate with carnivore species in different beats	61
4.3.7.	Food habits of leopard	67
5	SOCIO-ECONOMIC PROFILE AND RESOURCE DEPENDENCY OF LOCAL PEOPLE	69
5.1.	Introduction	69
5.2.	Methodology	71
5.3.	Results	72
5.3.1.	People and livestock	72
5.3.2.	Socio-economics	84
5.4.	Discussion	109
5.5.	Recommendations	116
6	References.	120



## LIST OF TABLES

		Page No.
Table 2.1	Details of satellite imagery used	6
Table 2.2	Vegetation and land cover classes in Sariska Tiger Reserve	9
Table 2.3	Vegetation and land cover classes in Sariska range	11
Table 2.4	Vegetation and land cover classes in Akbarpur range	12
Table 2.5	Vegetation and land cover classes in Talvriksh range	12
Table 2.6	Vegetation and land cover classes in Tehla range	13
Table 2.7	Major roads in Sariska Tiger Reserve	18
Table 2.8	List of major water-bodies in Sariska Tiger Reserve.	20
Table 3.1	Range wise details of line transects	31
Table 3.2	Density, cluster size and group encounter rate of different prey species in Sariska Tiger Reserve	33
Table 3.3	Percentage abundance of the major prey species in Sariska Tiger Reserve	34
Table 3.4	Density, cluster size and group encounter rate of prey species in Sariska range	36
Table 3.5	Density, cluster size and group encounter rate of prey species in Akbarpur range	37
Table 3.6	Density, cluster size and group encounter rate of prey species in Tehla range	38
Table 3.7	Density, cluster size and group encounter rate of prey species in Talvriksh range	39
Table 3.8	The wild ungulate densities (per km <sup>2</sup> ) in Sariska Tiger Reserve (1991 to 2007)	41
Table 3.9	Wild ungulate densities reported (1997 to 2007) from various deciduous forests of the country	41



Table 4.1	Estimated density of leopard using different models	59
Table 4.2	Estimate of leopard density	59
Table 4.3	Estimated leopard density in Sariska Tiger Reserve (2005 to 2007)	60
Table 4.4	Reported leopard densities in different forest areas	60
Table 4.5.	Number of captures of different carnivore species in each camera trap locations	64
Table 5.1	Number of households surveyed and percent sampling achieved in villages of Core zone-I of Sariska Tiger Reserve	74
Table 5.2	Number of households surveyed and percent sampling achieved in other villages of Sariska Tiger Reserve (outside Core Zone-I)	74
Table 5.3	Demographic details of different villages in Core Zone-I of Sariska Tiger Reserve	75
Table 5.4	Demographic details of other villages of Sariska Tiger Reserve (outside Core Zone-I)	76
Table 5.5	Total livestock population in different villages in Core- Zone I of Sariska Tiger Reserve	81
Table 5.6	Total livestock population in different villages in Sariska Tiger Reserve (outside Core Zone-I)	82
Table 5.7	List of plant species exploited by the local people in Core Zone-I of Sariska Tiger Reserve	91
Table 5.8	Details of fodder exploitation, milk production, land holdings and grazing distance of livestock in different villages of Core Zone-I of Sariska Tiger Reserve	92
Table 5.9	Details of commercial value of fuelwood and fodder exploited by people in Core Zone-I of Sariska Tiger Reserve	93



Table 5.10	Income generations through selling milk in different villages surveyed in and around Sariska Tiger Reserve	97
Table 5.11	Reported Annual Income from different sources in different villages surveyed in Core Zone-I of Sariska Tiger Reserve	98
Table 5.12	Annual Income from different sources in different villages surveyed outside Core Zone-I of Sariska Tiger Reserve	99
Table 5.13	Details of land holdings among different villages surveyed in and around Sariska Tiger Reserve	100
Table 5.14	Percentage of respondents to various socioeconomic and awareness questions in three different categories of the villages surveyed in and outside Sariska Tiger Reserve	103



## LIST OF FIGURES

		Page No.
Figure 1.1	Locations of villages in Core Zone-I (notified National Park) of Sariska Tiger Reserve	2
Figure 2.1	Location and administrative boundary of Sariska Tiger Reserve	14
Figure 2.2	Beat map of Sariska Tiger Reserve	15
Figure 2.3	Range map of Sariska Tiger Reserve	16
Figure 2.4	Location of forest huts (Chowkis) in Sariska Tiger Reserve	17
Figure 2.5	Major roads in Sariska Tiger Reserve	18
Figure 2.6	Natural water bodies and artificial water points in Sariska Tiger Reserve	20
Figure 2.7	Contour map of Sariska Tiger Reserve	22
Figure 2.8	Drainage map of Sariska Tiger Reserve	23
Figure 2.9	Slope map of Sariska Tiger Reserve	24
Figure 2.10	Aspect map of Sariska Tiger Reserve	25
Figure 2.11	Hill shade map of Sariska Tiger Reserve	26
Figure 2.12	Digital elevation model of Sariska Tiger Reserve	27
Figure 2.13	Vegetation and land cover map of Sariska Tiger Reserve	28
Figure 2.14	False Color Composite map of Sariska Tiger Reserve and surrounding areas	29
Figure 3.1	Line transect locations on the beat map of Sariska Tiger Reserve	32
Figure 3.2	Densities of different prey species in Sariska Tiger Reserve	34
Figure 3.3	Densities of different prey species in Sariska range	36
Figure 3.4	Densities of different prey species in Akbarpur range	37
Figure 3.5	Densities of different prey species in Tehla range	38
Figure 3.6	Densities of different prey species in Talvriksh range	39



Figure 3.7	Abundance of prey species in different ranges	
Figure 3.8	Beat wise encounter rate of chital	42
Figure 3.9	Beat wise encounter rate of sambar	43
Figure 3.10	Beat wise encounter rate of nilgai	44
Figure 3.11	Beat wise encounter rate of wild pig	45
Figure 3.12	Beat wise encounter rate of buffalo	46
Figure 3.13	Beat wise encounter rate of cattle	47
Figure 3.14	Beat wise encounter rate of goats	48
Figure 3.15	Beat wise encounter rate of livestock	49
Figure 3.16	Beat wise encounter rate of peafowl	50
Figure 3.17	Beat wise encounter rate of common langur	51
Figure 4.1	Camera trap locations on Google earth imagery of Sariska Tiger Reserve	54
Figure 4.2	Cumulative number of leopard photographs and individual leopard captured with increasing sampling occasions	55
Figure 4.3	Population saturation of leopard with standard deviation as error bar	55
Figure 4.4	Camera trap locations with half MMDM buffer strip width showing the capture points of leopard in Sariska Tiger Reserve	56
Figure 4.5	Percent capture of individual leopard in Sariska Tiger Reserve	57
Figure 4.6	Leopard camera trap locations and area covered in Sariska Tiger Reserve	58
Figure 4.7	Encounter rates of wild ungulates in the beats where camera trapping was done in Sariska Tiger Reserve	61
Figure 4.8	Capture rate (per 100 trap nights) of carnivore species in different beats in Sariska Tiger Reserve	62
Figure 4.9	Comparison of leopard capture rate with human disturbance in effective trapping area of STR	63
Figure 4.10	Locations of caracal (based on secondary data) in Sariska Tiger Reserve	66
Figure 4.11	Percent occurrence of prey items in the diet of leopard (n=66) in Sariska Tiger Reserve	67



Figure 5.1	Human sex ratios in different villages in Core zone I in Sariska Tiger Reserve	77
Figure 5.2	Human sex ratios in other villages surveyed in Sariska Tiger Reserve	77
Figure 5.3	Literacy rate among the villagers in different villages in Core Zone I of Sariska Tiger Reserve	78
Figure 5.4	Literacy rate among the villagers in other villages of Sariska Tiger Reserve	78
Figure 5.5	Percent occurrence of different livestock species in the villages in Core Zone I of Sariska Tiger Reserve	83
Figure 5.6	Observed difference in the total livestock population from 2004 to 2008 in 10 villages of Core Zone-I of Sariska Tiger Reserve	83
Figure 5.7	Quantity of fuelwood in kilograms exploited per day by the villages located in Core zone I of Sariska Tiger Reserve	94
Figure 5.8	Quantity of fuelwood in kilograms exploited per day by the other villages of Sariska Tiger Reserve (excluding Core Zone-I)	94
Figure 5.9	Quantity of fodder in kilograms exploited per day for the livestock in villages located in Core Zone-I of Sariska Tiger Reserve	95
Figure 5.10	Quantity of fodder in kilograms exploited for the livestock per day in other villages of Sariska Tiger Reserve (excluding Core Zone-I)	95
Figure 5.11	Total liters of milk produced and sold among the sampled households in villages of Core Zone-I of Sariska Tiger Reserve	96
Figure 5.12	Total liters of milk produced and sold among the sampled households in other villages of Sariska Tiger Reserve (excluding Core Zone-I)	96
Figure 5.13	Percent of households owning land in different villages surveyed in and around Sariska Tiger Reserve	101



Figure 5.14	Average distance covered for grazing by the livestock in different villages in Core Zone-I of Sariska Tiger Reserve	101
Figure 5.15	Average distance covered for grazing by the livestock in other villages of Sariska Tiger Reserve	102
Figure 5.16	Different anthropogenic factors reported from villages in Core Zone-I in Sariska Tiger Reserve	102
Figure 5.17	Intensity of wood cutting in Sariska Tiger Reserve	105
Figure 5.18	Intensity of lopping in Sariska Tiger Reserve	106
Figure 5.19	Intensity of grazing in Sariska Tiger Reserve	107
Figure 5.20	Livestock grazing influence zones around each village in Sariska Tiger Reserve	108

## INTRODUCTION



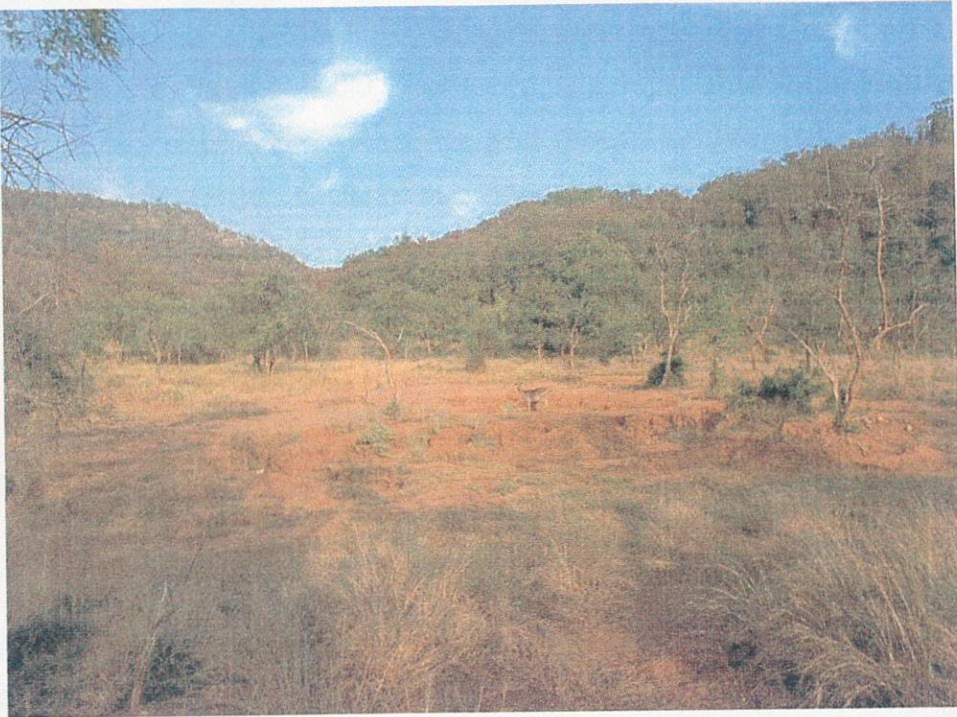
## ACKNOWLEDGEMENT

Dr. Rajesh Gopal, Member Secretary, National Tiger Conservation Authority (NTCA), Ministry of Environment and Forests, Government of India, New Delhi, is thanked for providing funds to conduct the study in Sariska. The Chief Wildlife Warden, Rajasthan, Sh. R. N. Mehrotra, Field Director, Sh. Somasekhar, Deputy Director Sh. Rajesh Gupta, Range officers Sh. Daulatsingh and Sh. A. K. Jha and all the staff of Sariska Tiger Reserve extended utmost cooperation during the field work at Sariska.

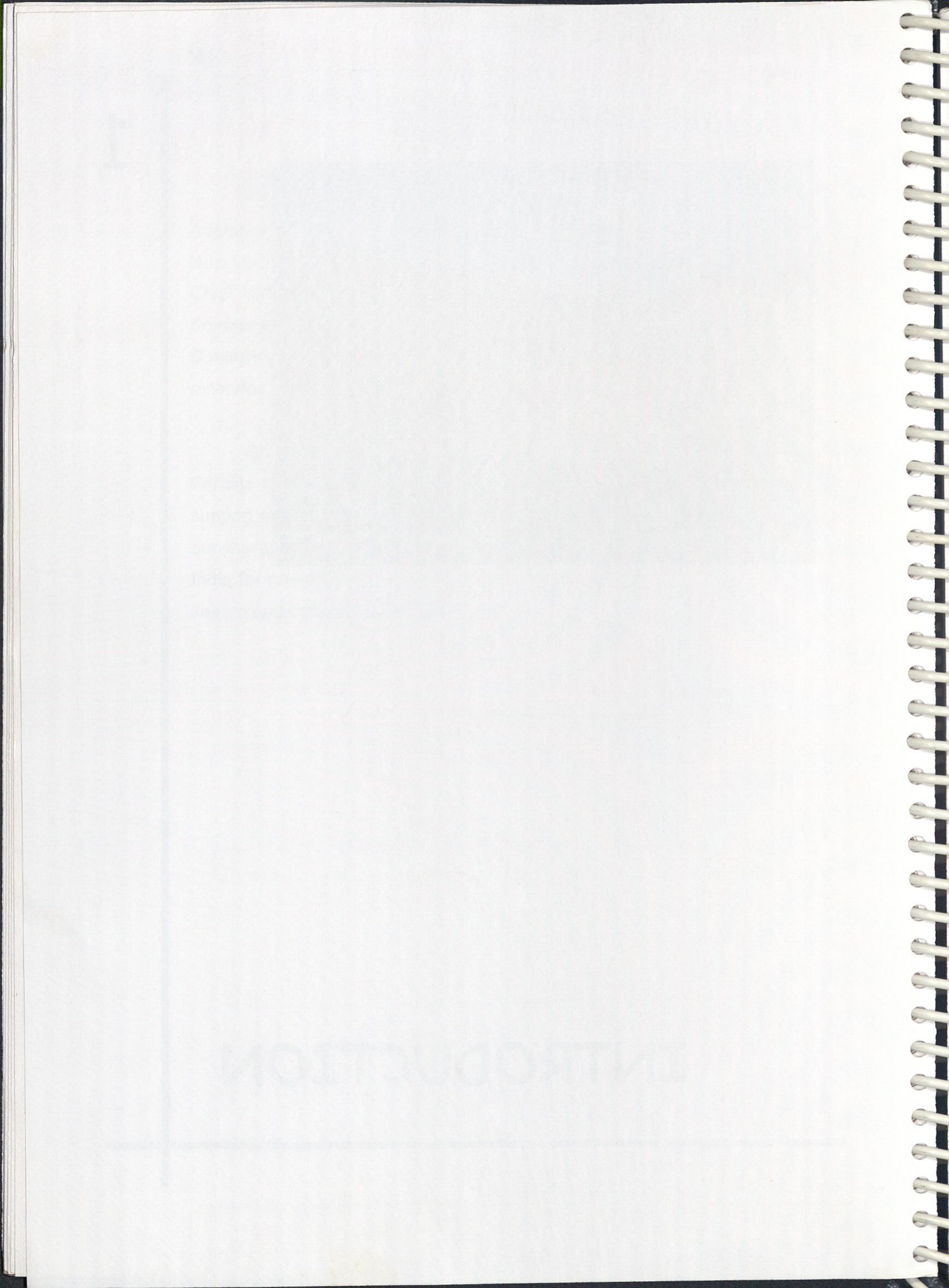
Sh. P. R. Sinha, Director, and Dr. V. B. Mathur, Dean of Faculty, of Wildlife sciences, Wildlife Institute of India, are thanked for the guidance and support extended to this project. The study would not have been possible without the support from Ms. Nilanjana and Ms. Parabita of Wildlife Institute of India for preparing the maps and our field assistants Omi, Chhotu, Ramesh, Jairam and Dataram at Sariska.

# INTRODUCTION

1



# INTRODUCTION





## 1. INTRODUCTION

Sariska Tiger Reserve (STR) is the third largest protected area among the 93 protected areas in India's semi arid region situated in the semi arid biogeographic zone of India (Rodgers and Panwar 1988), the area extends between 76°17'-76°34' N latitudes and 27°05'-27°33' longitudes, part of district Alwar in Rajasthan. The total area of Tiger reserve is Area: 886 sq. km, out of which Core zone comprises of 497 sq. km, and Buffer area of 384 sq. km. Sariska core zone is in three isolated pockets. Core-I (273.8 km<sup>2</sup>), II (126.5 km<sup>2</sup>), and III (97.5 km<sup>2</sup>). The status of Core-I has been notified as a National Park in 1982.

The major part of the area is occupied by rocks of the Delhi system and Aravalli system comprising of quartzites, conglomerates, grits, limestone, phyllites, granites and schists (Pascoe 1950; Sankar 1994). The climate is subtropical, characterized by a distinct winter, summer, monsoon and post-monsoon. Winter commences from November. In winter the temperature has been observed to drop occasionally to 0°C. Summer commences from mid March and continues till end of June. July to September are rainy season. Bulk of the rainfall is from south west monsoon during July and August. The study area also receives occasional winter and summer rains. Average rainfall recorded was 650 mm (Sankar 1994).

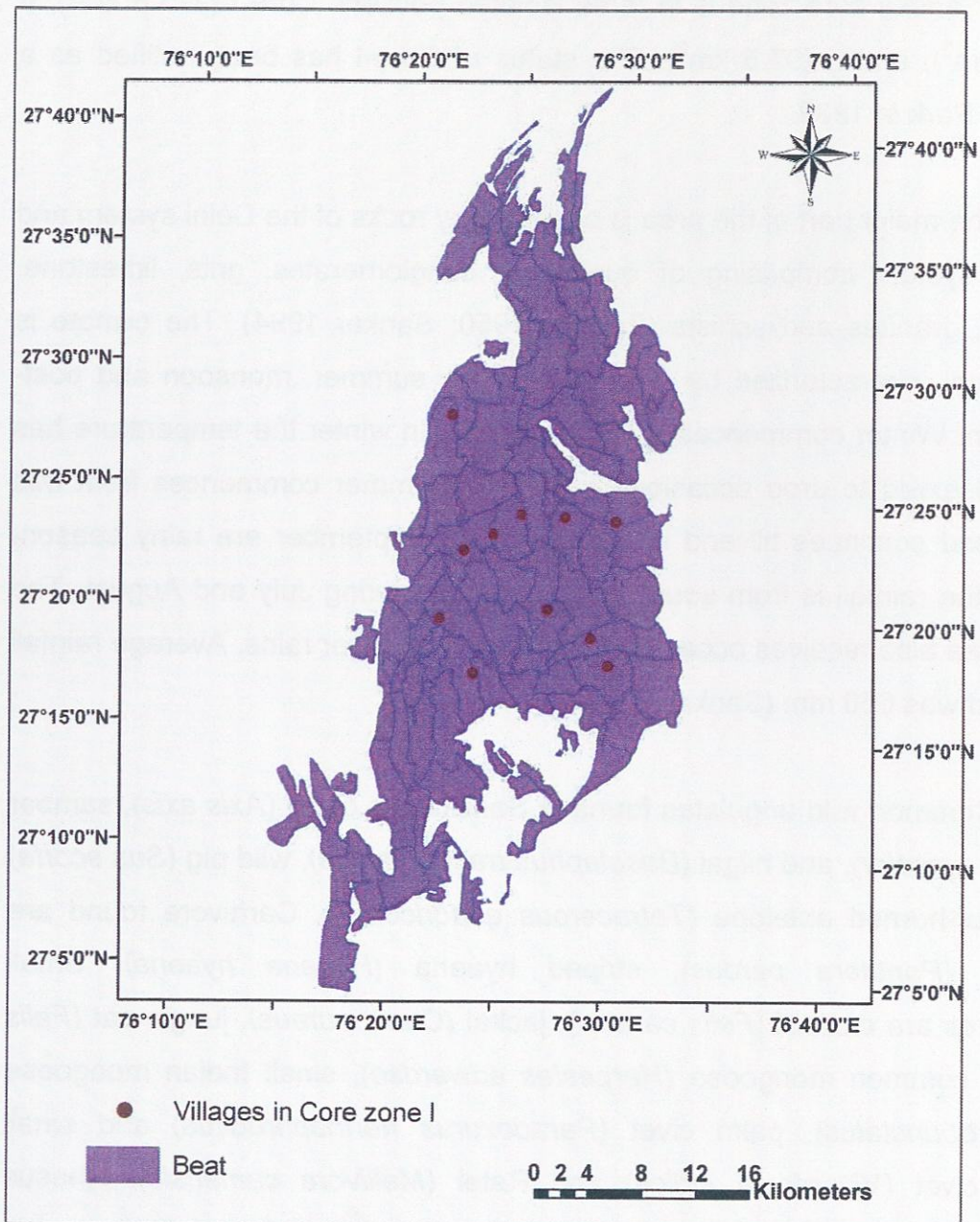
Common wild ungulates found in Sariska are chital (*Axis axis*), sambar (*Cervus unicolor*), and nilgai (*Boselaphus tragocamelus*), wild pig (*Sus scrofa*) and Four-horned antelope (*Tetracerous quadricornis*). Carnivore found are leopard (*Panthera pardus*), striped hyaena (*Hyaena hyaena*). Small carnivores are caracal (*Felis caracal*), jackal (*Canis aureus*), jungle cat (*Felis chaus*), common mongoose (*Herpestes edwardse*), small Indian mongoose (*H. auropunctatus*), palm civet (*Paradoxurus hermaphroditus*) and small Indian civet (*Viverricula indica*) and Ratel (*Mellivora camensis*). Rhesus monkey (*Macaca mulatta*) and common langur (*Presbytis entellus*) are the



two primates found. Procupine (*Hystrix indica*), Rufous tailed hare (*Lepus nigricollis ruficaudatus*) also occur in Sariska (Sankar 1994).

There are 32 forest villages located inside the Sariska Tiger Reserve, of which 13 are located in and around the out-skirts of the Buffer zone and 10 villages are situated in the Core-I (Fig. 1.1).

**Figure 1.1. Location of villages in Core Zone - I (Notified National Park) of Sariska Tiger Reserve.**





Eleven villages are due for relocation since 1984 in the notified National Park of the reserve. Besides this, there are six grazing camps or *Guadas* namely Kankwari, Umri, Haripura, Lilunda, Sukola and Rotkala in Core I. In the revenue villages the economy of the people is based on agriculture and in the grazing camps it is animal husbandry. A large number of buffaloes and goats, a few cattle and camel are kept in the villages. Thousands of migratory sheep pass through the buffer zone during July to October (Sankar 1994).

### OBJECTIVES:

The Project Tiger, Ministry of Environment & Forests, Government of India, New Delhi assigned the following tasks to Wildlife Institute of India vide letter 1-9/93-PT(Part) dated 18<sup>th</sup> February, 2005:

1. To address the distribution and status of tigers and co-predators.
2. To address the distribution and status of prey species.
3. To prepare vegetation and land cover map of Sariska TR.
4. To study the socio economic profile and resource dependency of local people in the notified national park area and
5. To identify potential areas for 'source' population and areas warranting restorative action for corridor connectivity to facilitate gene flow.

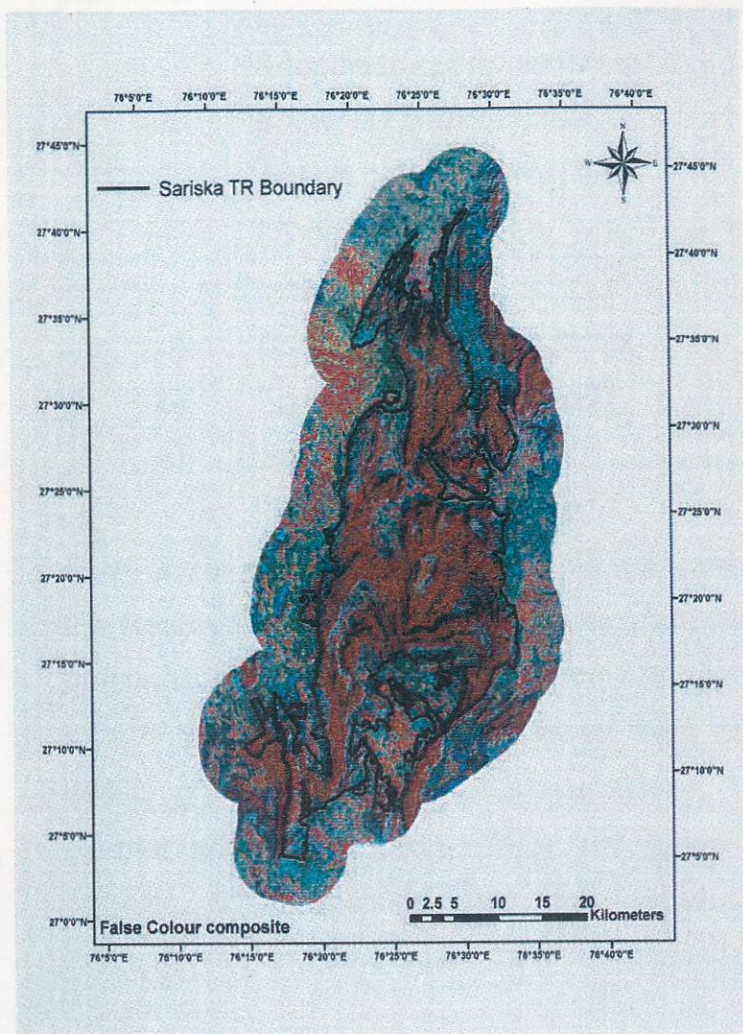
The first and fifth objectives were already addressed and a report on 'Assessment of status of tiger (*Panthera tigris*) in Sariska Tiger Reserve, Rajasthan' was submitted to the Project Tiger, Ministry of Environment & Forests, Govt. of India, New Delhi (Sankar *et al* 2005) (**Annexure I**). The remaining objectives as mentioned above are being addressed in the present study. The outcome of the study will form a basis for preparing a Management Plan for Sariska Tiger Reserve.

## 2. VEGETATION AND LAND COVER OF SARISKA TIGER RESERVE

### 2.1. INTRODUCTION

Information about extent, composition and the transformation of landscape are important to understand potential of given area. The principal source of such information has been vegetation mapping. Vegetation maps provide basis for planning and management and for detailed habitat inventories. The design and execution of these comprehensive inventories should be based on a clear definition of management priorities. Vegetation management depends upon a classification of habitats. Regular and continuous monitoring of the habitats permits the detection of change in vegetation components and immediate surroundings (Mooney and Chapin 1994).

The vegetation of Sariska is classified as to (1) Northern tropical dry deciduous forests (subgroups 5B; 5/E1 and 5/E2) and Northern Tropical Thorn forest (subgroup 6B) (Champion and Seth 1986). *Anogeissus pendula* is the dominant tree species covering over 45 per cent area of the forest. *Boswellia serreta* and *Lannea coromandelica* grow at rocky patches. *Acacia catechu* and bamboo are common in the valleys. Some valleys support *Butea monosperma* and *Zizyphus mauritiana*. *Dendrocalamus strictus* is extremely limited in distribution and is found along well drained reaches of the streams and moist and cooler parts of the hills. *Albizia lebbeck*, *Diospyros melanoxylon*, *Holoptelia integrifolia* and *Ficus sp* are found in moist localities. (Sankar 1994). A number of exotic invasive species have become common in the human used areas of the Reserve, such as the annual shrub *Cassia tora* and the short-statured tree *Prosopis juliflora*. *Adhatoda vasica*, though a native under storey species, has become very common in disturbed and over-grazed areas, and appears to suppress grass and other native herbaceous species. Parmar (1985) and Rodgers (1985) have classified vegetation of Sariska as follows:



## VEGETATION AND LAND COVER OF SARISKA TIGER RESERVE



1. *Anogeissus pendula* forest
2. *Boswellia serrata* forest
3. *Acacia catechu* forest and
4. *Miscellaneous forest*, which can be further sub-divided into three categories viz.
  - a) *Butea monosperma* forest
  - b) Forest along nallas and
  - c) Scrub land

Most of the resident people, living in 10 small hamlets inside Core Zone I of the Reserve, are livestock herders by profession and graze mostly goats and buffaloes, sheep and cows. Their only source of income is the production of milk and milk-based products. Apart from grazing, local people commonly collect grasses and lop forest vegetation for stall feeding their livestock (Kumar and Shahabuddin 2003) and collect deadwood and tree branches from the STR forests to meet their fuel wood requirements. A number of fruits, leaves and other plant parts are used for food and medicine.

Remote Sensing and the processing of remotely sensed data through Geographical Information System (GIS) are two most important synergistic technologies which offer ecologists and resource managers, tools of tremendous potential value to address their needs and process their information (Roughgarden *et al.* 1991 and Sample 1994a). Cornett (1994) and Sample (1994b) emphasize that GIS and Remote Sensing are catalysts for effective public involvement in ecosystem management planning, analysis and policy making.

Satellite remote sensing data has emerged as a potential tool to study land cover, vegetation type, geomorphology, hydro-geology and human interventions at fine to coarse scales (Haridas *et al.*, 1994; Kim and Weaver, 1994; Krishnmurthy and Srinivas, 1996; Pradeep *et al.*, 1996; Rao *et al.*, 1996; Tripathi *et al.*, 1996; Jain 1998 and Mathur and Naithani 1999). The data provides details on habitat with very high accuracy and at low cost effective manner.



## 2. 2. METHODOLOGY

### 2. 2. 1. Data source

False Colour Composites (FCC) of Landsat -7 – ETM+ imagery for the month of September 2000 was used and the details of the same are given in **Table 2.1.**

**Table 2.1. Details of satellite imagery used**

Satellite	Landsat 7
Sensor	ETM+
FCC bands	4,3,2 (RBG)
Projection	Universal Transverse Mercator (UTM)
Datum	Geocoded
Resolution	28.5 meters
Date of Acquisition	2000-09-13
Path	147
Row	041
RMS Error	7m

Data from Landsat 7 is collected and distributed (<http://glcf.umiacs.umd.edu/index.shtml>).

## 2. 3. DATA PROCESSING AND ANALYSIS

### 2. 3. 1. Satellite data:

The satellite data was processed using ERDAS-Imagine 8.3 and ARCInfo 7.1.2 software. The geo-rectified data has root mean square (RMS) error of 7 m. The desired area was extracted from each scene. Mosaicing and featuring was done to join the two images. A False Color Composite (FCC) was generated for the entire Tiger Reserve.



### **2. 3. 2. Survey of India toposheets:**

The park boundary, drainage, contour and other important locations were extracted from the SOI toposheets and digitised on 1:50,000 scale. The RMS error for digitised data was 3.2 m. Later, these layers were digitized independently using ARC/INFO software. The digitized information was then registered in GIS domain.

### **2. 3. 3. Vegetation and land cover mapping:**

The Landsat ETM+ digital data was processed using unsupervised maximum likelihood classification procedure. Thirty classes were extracted for field validation. A map with different colour tones for 30 classes was prepared. This map was carried to the field and interpretation of each colour tone classes was done. The ground truthing for vegetation and land cover was conducted from November 2006 to June 2007. In total, 327 circular plots (10 m radius for trees & shrubs) were laid along the line transects at every 400 m interval in every beat. GPS locations were taken for all the sampled plots to help in classification of different vegetation types and accuracy assessment. Necessary correction was then incorporated on unsupervised map and accordingly the final rectification was done. The colour classes were merged depending on the similarity in vegetation types. The map was further improved using supervised maximum likelihood classifier to incorporate unclassified and misclassified data. Nine vegetation and land cover classes were identified in the final map output. The overall classification accuracy is determined to be 80%.

### **2. 3. 4. Park infrastructure mapping:**

Between November 2006 and June 2007 fieldwork was carried out in STR for the infrastructure mapping. Location of major roads, management units like, natural and artificial water bodies, forest huts (chowkis) were being taken with the help of Global Positioning System (GPS). A data base file of all GPS locations taken for the infrastructure was created and linked to the spatial data in GIS domain.



## 2. 4. RESULTS AND INTERPRETATION OF MAPS

### 2. 4. 1. General Maps

**Sariska Tiger Reserve Location and administrative boundaries:** The geographical location of STR within the country, Rajasthan State, and Biogeographic Zone is given in **Map 2.1**. The total area of the Tiger Reserve is 886 km<sup>2</sup>. Beats and Ranges found in tiger reserve are given in **Map 2.2 and 2.3** respectively. In total there are 75 beats and 4 ranges (Akbarpur, Sariska, Talvirishk, and Tehla) in STR. The range wise distribution of different forest huts (Chowkis) is shown in **Map 2.4**. In total there are 47 chowkis (7 in Talvirishk Range, 8 in Akbarpur Range, 5 in Sariska Range, 10 in Tehla Range and 17 in the surrounding areas. The major road network in STR is shown in **Map 2.5**. There are two state highways (Alwar – Jaipur and Alwar - Dausa) passing through the notified National Park area. Range wise location of Natural water bodies and artificial water points is shown in **Map 2.6**. STR has an undulating terrain with altitude varying between 280 m and 720 m. The mean altitude of the area is 500 m. The terrain in Tiger Reserve is comparatively more rugged than surrounding areas. The detailed outlay of the contours of STR is given in **Map 2.7**. The drainage pattern of STR is given in **Map 2.8**. The Ruparel River runs through the middle of the Tiger Reserve in North South direction for 74 km in the Tiger Reserve. The drainage from most areas of the northern portion of the Tiger Reserve including Bandipul stream flows into the Ruparel River, while the drainage of the southern part of the Tiger Reserve flows into the Mansarovar Lake. The slope categories of STR have been demarcated under 5 classes (0-10, 11-20, 21-40, 41-60, >60). Most of the Tiger Reserve area falls under flat to gentle slope category. A detailed outlay of the slope of STR is given in **Map 2.9**. The different aspect of the slopes of STR is shown in **Map 2.10**. These include North, Northeast, East, Southeast, South, Southwest, West and Northwest. The hill shade map of STR showing three different illumination ranges (low, medium and high) is given in **Map 2.11**. The Digital Elevation Model of STR is given in **Map 2.12**.



**Vegetation and Landcover:** Nine different vegetation and land cover categories have been delineated in STR (**Map 2.13**) based on landsat data (**Map 2.14**). They are *Anogeissus* dominated forest, *Boswellia* dominated forest, *Butea* dominated forest, *Acacia* mixed forest, *Zizyphus* mixed forest, Scrubland, Agricultural land, Water body and Barren land. The percentage proportion of above mentioned vegetation and land cover categories are given in **Table 2.2**.

**Table 2. 2. Vegetation and land cover classes in Sariska Tiger Reserve**

Vegetation/Landcover type	Area (sq. km.)	Percentage
<i>Anogeissus</i> dominated forest	283.250	35.431
Scrubland	152.463	19.071
<i>Boswellia</i> dominated forest	123.538	15.453
Agriculture/Habitation	74.677	9.341
<i>Butea</i> dominated forest	63.559	7.950
<i>Zizyphus</i> mixed forest	47.511	5.943
<i>Acacia</i> mixed forest	32.188	4.026
Barren land	20.625	2.580
Water body	1.621	0.203
<b>Total</b>	<b>799.432</b>	<b>100</b>

***Anogeissus* dominated forest:** The *Anogeissus pendula* that occupies 35.4% of the overall vegetation types is the dominant vegetation type in the entire STR distributed largely in gentle slopes. This species is found in association with *Acacia catechu* and *Lanea coromandelica*. The under storey is formed by *Adathoda vasica*, *Grewia flavescens*, *Caparis separia* and *Nycatanthus sp.* Ground cover mainly comprises of *Aristida sp.*, *Setaria sp* and *Chloris sp.*

***Boswellia* dominated forest:** *Boswellia serrata* that occupies 15.4% of the overall vegetation types is found largely in steep slopes and plateaus. This

species is found in association with *Anogiessus pendula*, *Doispyros melanoxyton*, *Acacia catechu*, *Wrightia tinctoria*, *Bahunia racemosa*, and *Ehritia racemosa*. The under storey comprises of *Eurphobia nerifolia*, *Grewia flavescens*, *G. tenax* and *Caparis sepiaria*. Grass cover is sparse and is formed by *Aphluda sp* and *Chloris sp*.

**Butea dominated forest:** *Butea* dominated forest occupies 7.9% of the Tiger Reserve. This species is found in association with *Ziziphus mauritiana*, *Cordia myxa*, *Phoenix Sylvesteris* (along the streams), *Holoptelea integrifolia* and *Cassia fistula*. The *Caparris sepiaria*, *Grewia flavescence*, and *Rhus mysorenses* are the common under storey. Ground layer comprises of *Heteropogon contortus* and *Chloris dolichostachya*.

**Scrubland:** This vegetation type occupies 19.1% of the forest cover in which the tree species such as *Prosopis juliflora*, *Acacia leucophlia*, *Acacia nilotica*, *Acacia senegal*, *Maytenus emarginata* and *Balanites aegyptiaca* are sparsely distributed. The under story is formed by *Caparis decidua*, *C. sepiaria*, *Rhus mysorenses*, *Grewia flavescens*, *G. tenax*, *Zizyphus nummularia*, *Adathoda vasica* and *Dicrostachys cinera*. Grass cover is sparse and is mainly formed by *Cynadon sp*, *Chloris sp*, *Sporobolus sp*, and *Synchrus sp*.

**Acacia mixed forest:** The *Acacia* mixed forest occupied 4% of the total vegetation types in STR. The *Acacia leucopholia* is the dominant vegetation type is found in association with *Prosopis juliflora*, *Acacia senegal*, *Dicrostachys cineria* and *Maytenus emarginata*. The understorey is formed by *Caparis sepiaria*, *D. cinera* and *M. emarginata*, Grasses found are *Apluda mutica*, *Cynodon dactylon* and *Desmostachya bipinnata*.

**Zizyphus mixed forest:** This vegetation community that occupies 5.9% of the total vegetation type in STR is dominated by *Ziziphus mauritiana* in combination with *Acacia catechu*, *A. leucopholia* and *B. monosperma*. The understorey is formed by *Adatoda vasica*, *Cassia tora*, *Caparis sepiaria* and *Zizyphus nummularia*. *Cynadon sp*, *Eragrostis sp*, and *Chloris sp* are typical grasses found along with this type of vegetation type.



The percentage occupancy of different vegetation types in different ranges of the Tiger Reserve is given table 2.3 to 2.6. The *Anogeissus* dominated forest is found in highest percentage in Sariska range. The *Zizyphus* mixed forest and *Butea* dominated forests which are important valley habitats are distributed in highest percentage in Sariska Range (18.8%).

**Table 2. 3. Vegetation and land cover classes in Sariska range**

Vegetation/Landcover type	Area (sq. km.)	Percentage
<i>Anogeissus</i> dominated forest	77.005	41.118
Scrubland	31.520	16.831
<i>Boswellia</i> dominated forest	30.494	16.283
Agriculture/Habitation	2.395	1.279
<i>Butea</i> dominated forest	15.550	8.303
<i>Zizyphus</i> mixed forest	19.684	10.512
<i>Acacia</i> mixed forest	7.376	3.939
Barren land	2.736	1.461
Water body	0.514	0.275
<b>Total</b>	<b>187.27</b>	<b>100.00</b>



Table 2. 4. Vegetation and land cover classes in Akbarpur range

Vegetation/Landcover type	Area (sq. km.)	Percentage
<i>Anogeissus</i> dominated forest	71.2041	37.968
Scrubland	36.970	19.713
<i>Boswellia</i> dominated forest	25.857	13.788
Agriculture/Habitation	14.066	7.500
<i>Butea</i> dominated forest	16.498	8.797
<i>Zizyphus</i> mixed forest	14.524	7.744
<i>Acacia</i> mixed forest	6.238	3.326
Barren land	2.182	1.163
Water body	0.009	0.005
<b>Total</b>	<b>187.54</b>	<b>100.00</b>

Table 2. 5. Vegetation and land cover classes in Talviriksh range

Vegetation/Landcover type	Area (sq. km.)	Percentage
<i>Anogeissus</i> dominated forest	98.196	35.272
Scrubland	56.421	20.266
<i>Boswellia</i> dominated forest	34.297	12.320
Agriculture/Habitation	42.391	15.227
<i>Butea</i> dominated forest	18.090	6.498
<i>Zizyphus</i> mixed forest	5.233	1.880
<i>Acacia</i> mixed forest	14.015	5.034
Barren land	8.655	3.109
Water body	1.098	0.394
<b>Total</b>	<b>278.396</b>	<b>100</b>



Table 2. 6. Vegetation and land cover classes in Tehla range

Vegetation/Landcover type	Area (sq. km.)	Percentage
<i>Anogeissus</i> dominated forest	36.845	25.200
Scrubland	27.552	18.844
<i>Boswellia</i> dominated forest	32.889	22.494
Agriculture/Habitation	15.826	10.824
<i>Butea</i> dominated forest	13.420	9.179
<i>Zizyphus</i> mixed forest	8.067	5.516
<i>Acacia</i> mixed forest	4.559	3.118
Barren land	7.052	4.823
<b>Total</b>	<b>146.21</b>	<b>99.9</b>

Figure 2. 1. Location and administrative boundary of Sariska Tiger Reserve

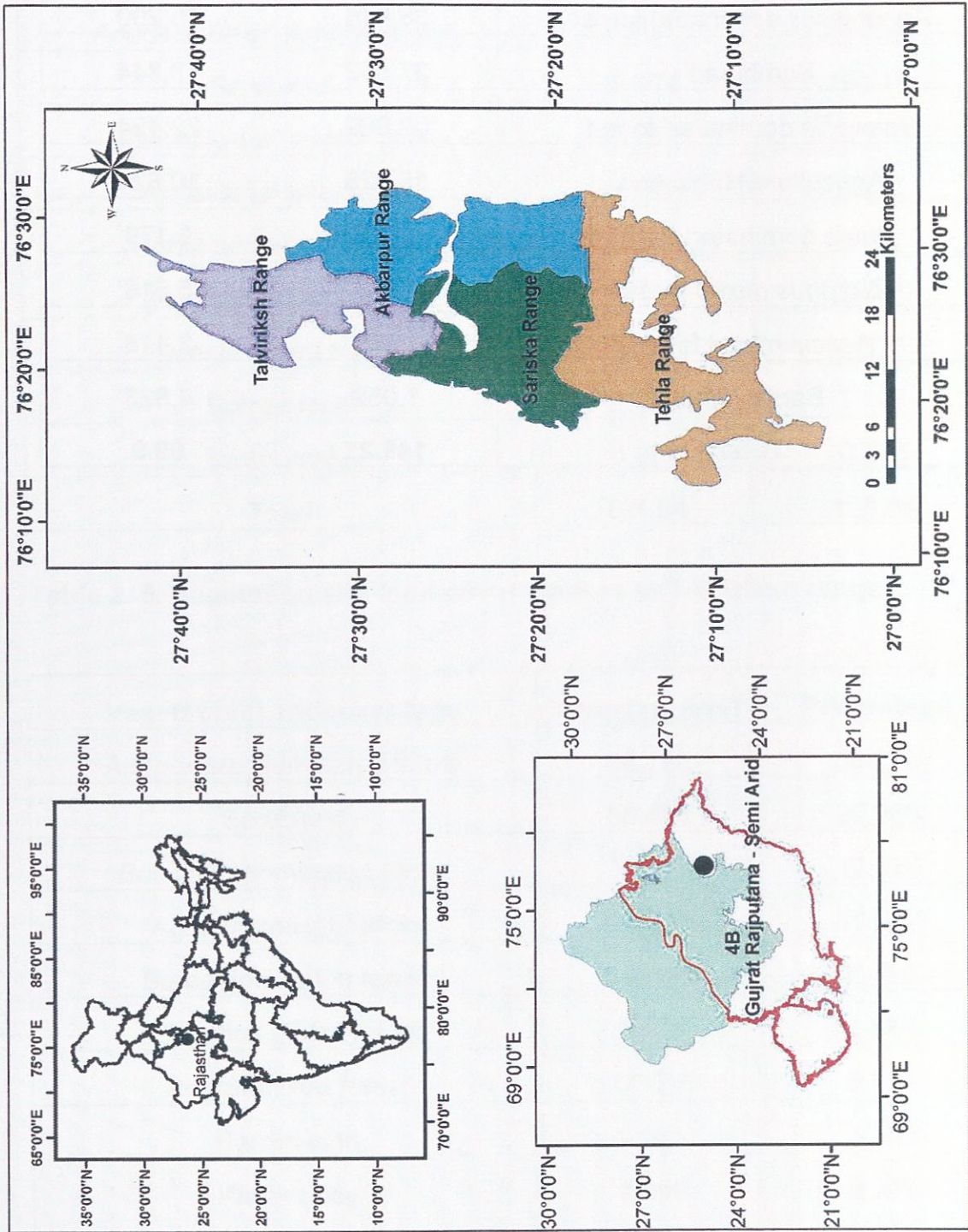




Figure 2. 2. Beat map of Sariska Tiger Reserve

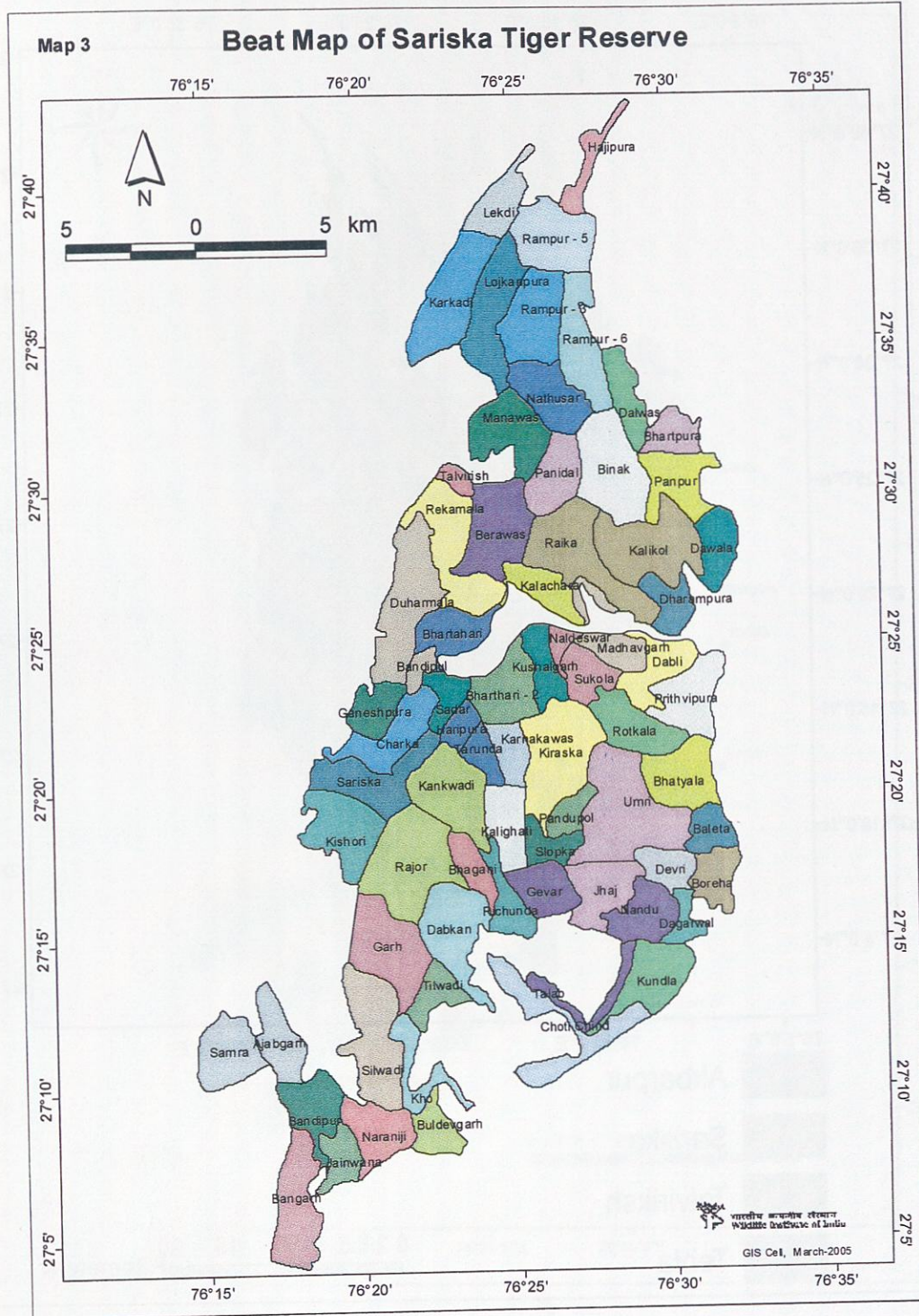




Figure 2. 3. Range map of Sariska Tiger Reserve

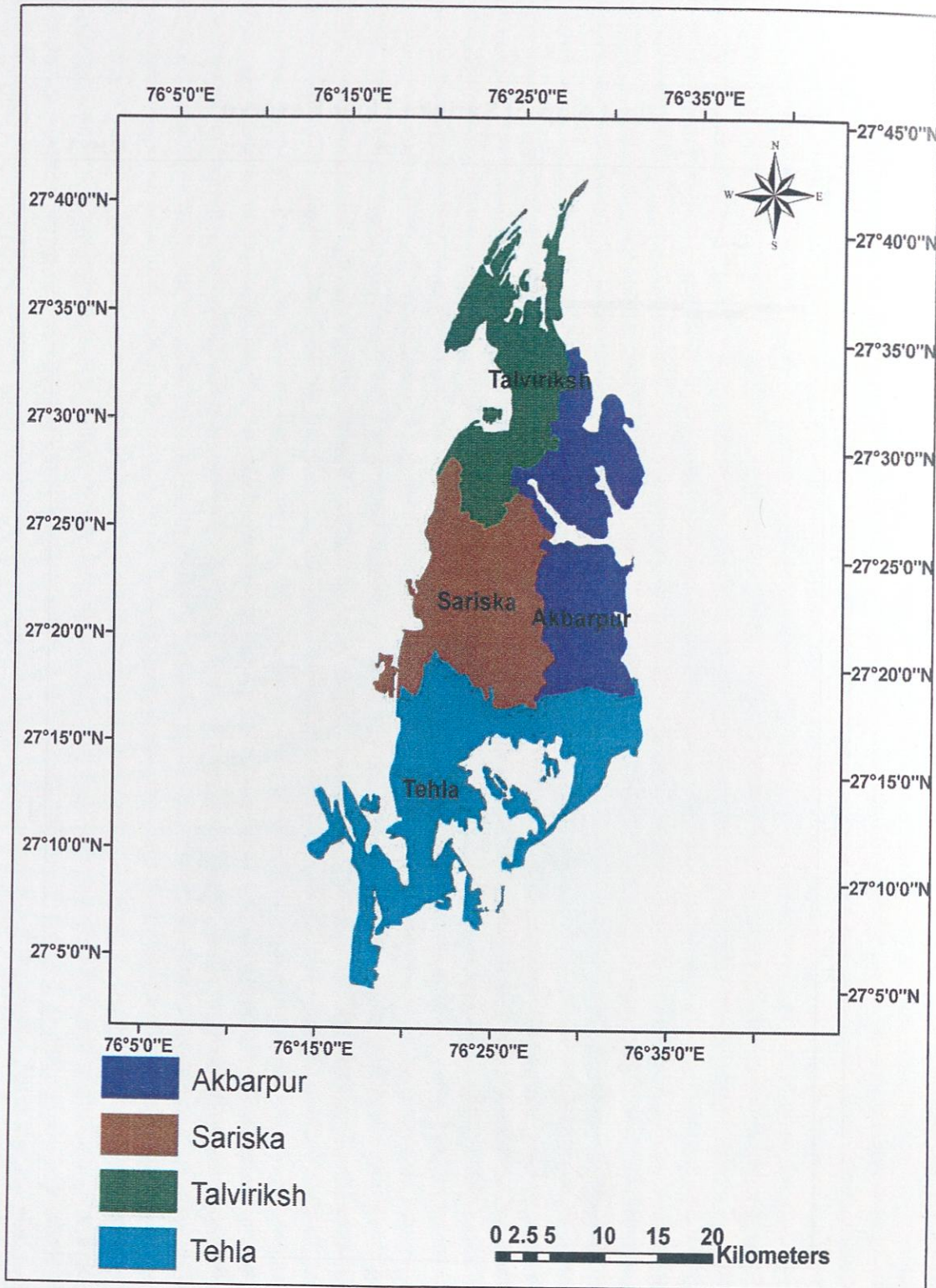




Figure 2. 4. Forest huts (Chowkis) in Sariska Tiger Reserve

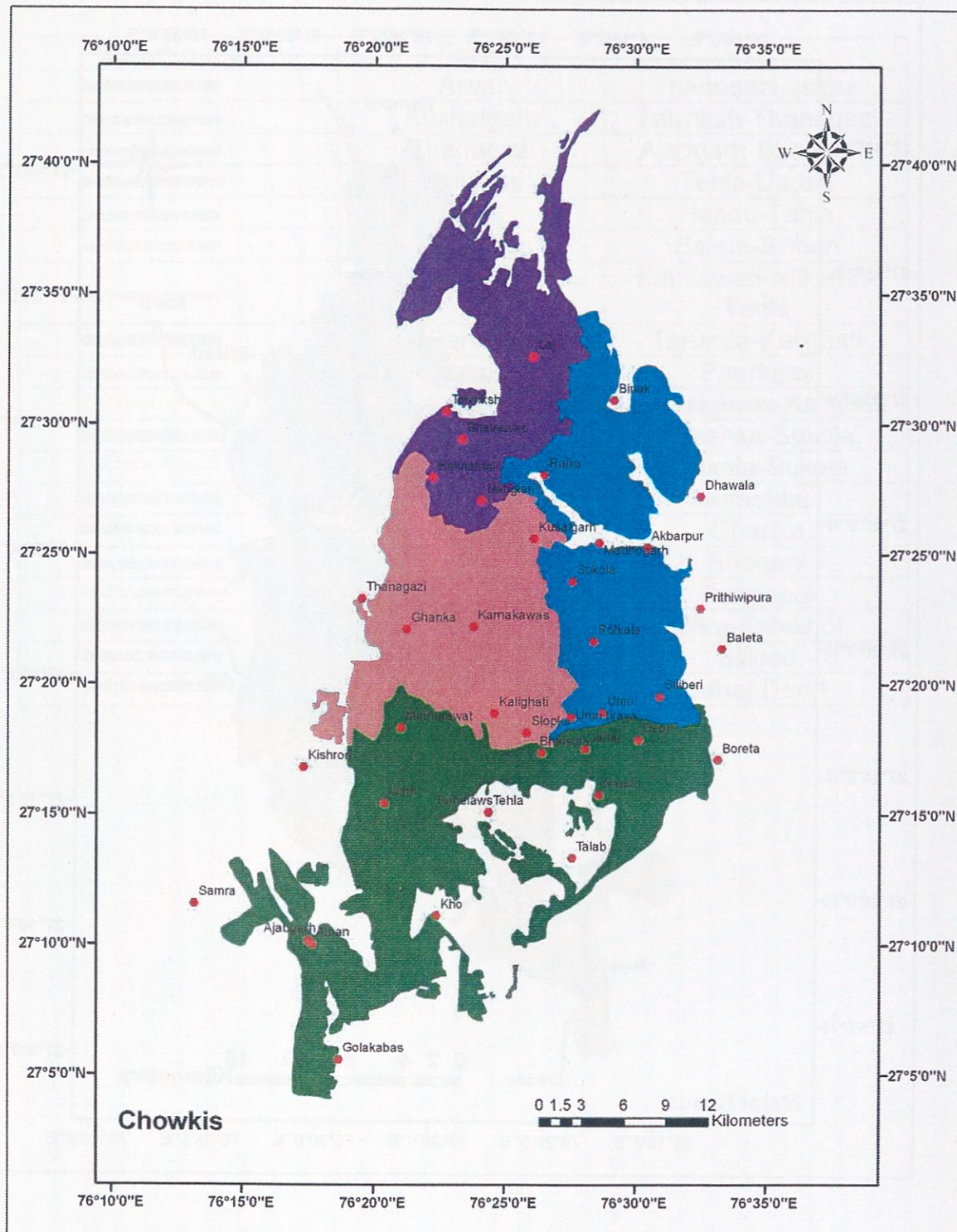




Figure 2. 5. Major roads in Sariska Tiger Reserve

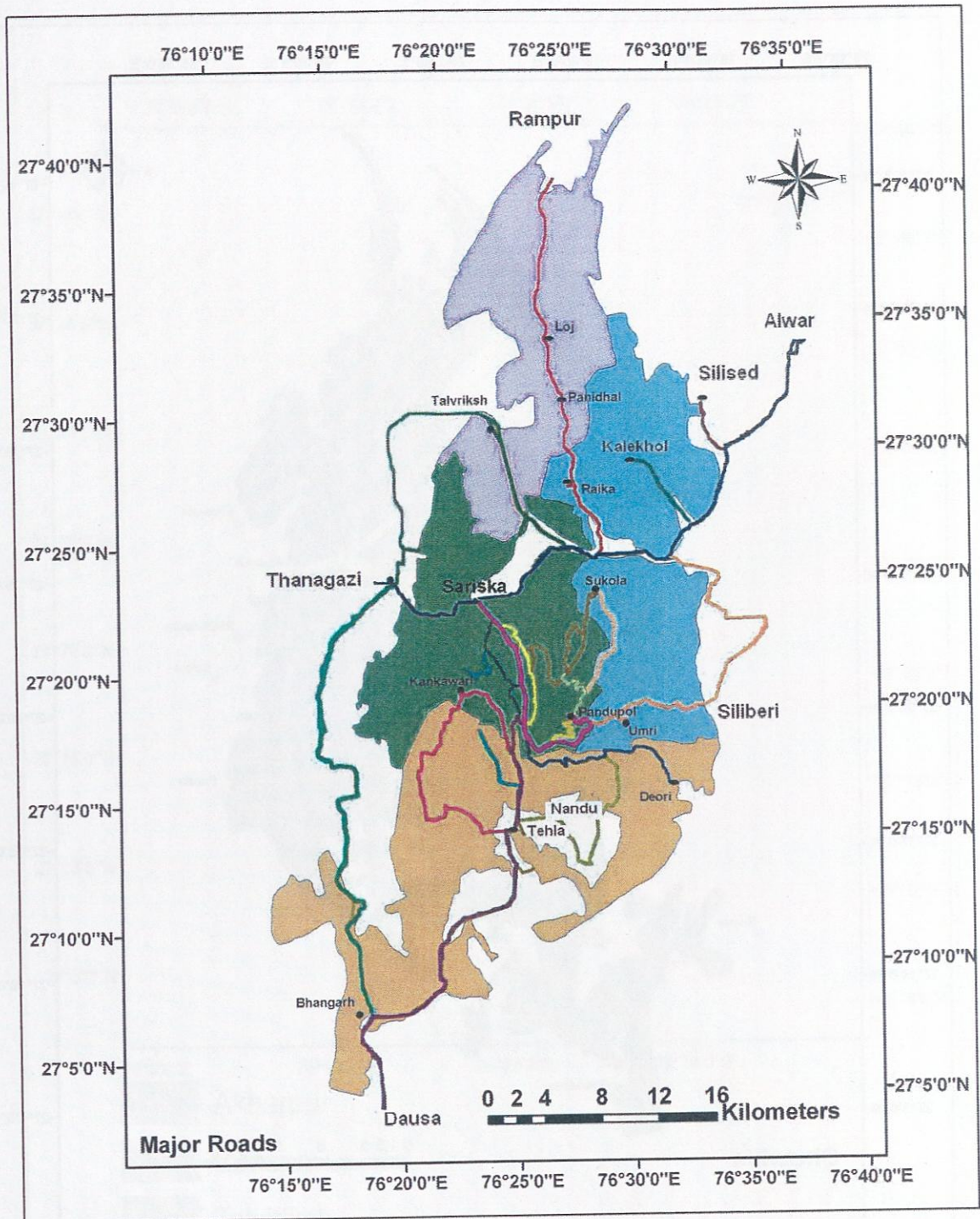




Table 2. 7. Major roads in Sariska Tiger Reserve

Color in map	From	To
	Alwar	Thanagazi-Jaipur
	Kushalgarh	Talvriksh-Thanagazi
	Thanagazi	Ajabgarh-Bhangarh
	Kalighati	Tehla-Dausa
	Jahaj	Nandu-Tehla
	Akbarpur	Baleta-Siliberi
	Richuna	Kankawari-Nilkanth-Tehla
	Sariska	Tarunda-Kalighati
	Sariska	Pandupol
	Sariska	Karnakawas-Kalighati
	Karnakawas	Kirashka-Sukola
	Bow	Rotkala-Sukola
	Pandupol	Kirashka
	Ghanka tiraya	Ghanka
	Richuna	Bhagani
	Slopka	Pandupol
	Dhawal	Bera-Kalekhol
	Kishanpur	Silised
	Kalighati	Jahaj-Deori



Figure 2. 6. Natural water bodies and artificial water points in Sariska Tiger Reserve

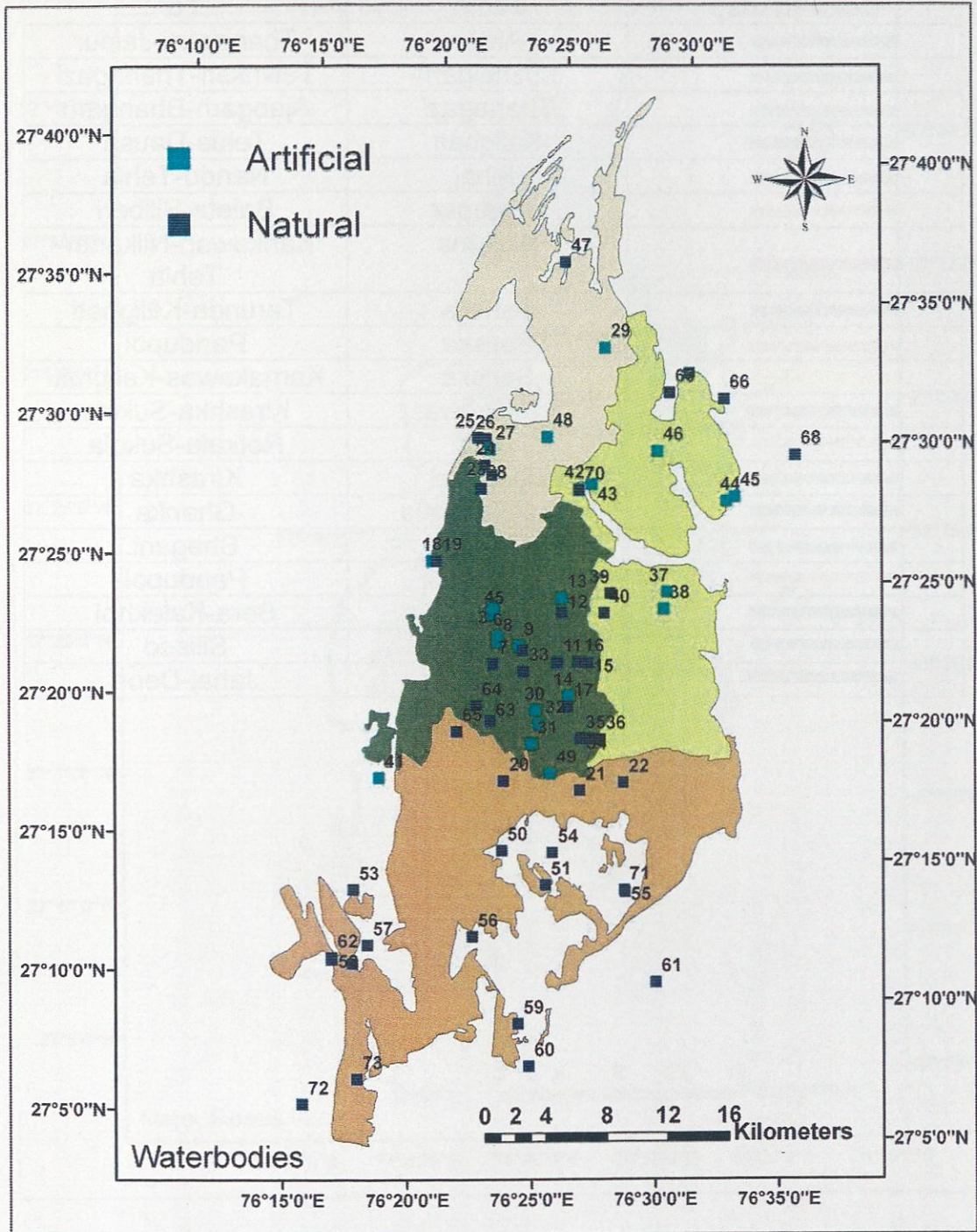




Table 2.8. List of major water-bodies in Sariska Tiger Reserve

No.	Name	Type	No.	Name	Type
1	Nursary Well	Artificial	38	Banni Ka Khoda	Artificial
2	Tiger Den Well	Artificial	39	Jora1	Natural
3	Well Behind FD House	Artificial	40	Jora2	Natural
4	Water Hole Behind Tiger	Artificial	41	Kishori Jora	Artificial
5	Gate Hand Pump	Artificial	42	Jora Near Village	Artificial
6	Haripura Well	Artificial	43	Chowki Wala Jora	Artificial
7	Tarundi Nala	Natural	44	Saiyad Anitkat	Artificial
8	Tbs Jora	Artificial	45	Dhwala Jori	Artificial
9	Karnakabas Well	Artificial	46	Bera Jora	Artificial
10	Karnakabas Anitkat	Natural	47	Modhawala Jora	Natural
11	Algual Nala	Natural	48	Sthital Nath Jora	Artificial
12	Lilunda Jora	Natural	49	Bherughati Anitkat	Artificial
13	Lilunda Well	Artificial	50	Man Sarobar	natural
14	Kiraska Jora	Artificial	51	Gura Bhairuji	natural
15	Kiraska Bandh	Natural	52	Sati Ka Jora	natural
16	Kiraska Jora 2	Natural	53	Samra Jora	natural
17	Nanglia Ka Jora	Natural	54	Nandu Jora	natural
18	Choya Anitkat	Artificial	55	Kundla Jora	natural
19	Choya Jora	Natural	56	Mangalsar	natural
20	Bediwala Dhaba	Natural	57	Ajabgarh Jora 1	natural
21	Bhesota Bera	Natural	58	Ajabgarh Jora 2	natural
22	Jahaj Nala	Natural	59	Gordhanpura Jora 1	natural
23	Dhokiwali Jori	Natural	60	Gordhanpura Jora 2	natural
24	Dodya Jora	Natural	61	Kundla Jora 1	natural
25	Jodimala Johdi	Natural	62	Ajabgarh Jora 3	natural
26	Hukli Jori	Natural	63	Kankawari Jora 1	natural
27	Lad Dengda Anitkat	Artificial	64	Kankawari Jora 2	natural
28	Akawala Jhogda	Natural	65	Mathurawat Jora	natural
29	Chowkiwala Jora	Artificial	66	Petpur Jora	natural
30	Brahmnath Water Hole	Artificial	67	Binak Jora	natural
31	Kalighati Waterhole	Artificial	68	Silised	natural
32	Behdawala Jora	Artificial	69	Bhakatpur Jora	natural
33	Tarunda Kunda	Natural	70	Raika Jora	natural
34	Budhehanuman	Natural	71	Kundala Jora	natural
35	Saran Ka Nala	Natural	72	Bhangarh Jora	natural
36	Makrunda	Natural	73	Jathwana Jora	natural
37	Meowala Jora	Artificial			



Figure 2. 7. Contour map of Sariska Tiger Reserve

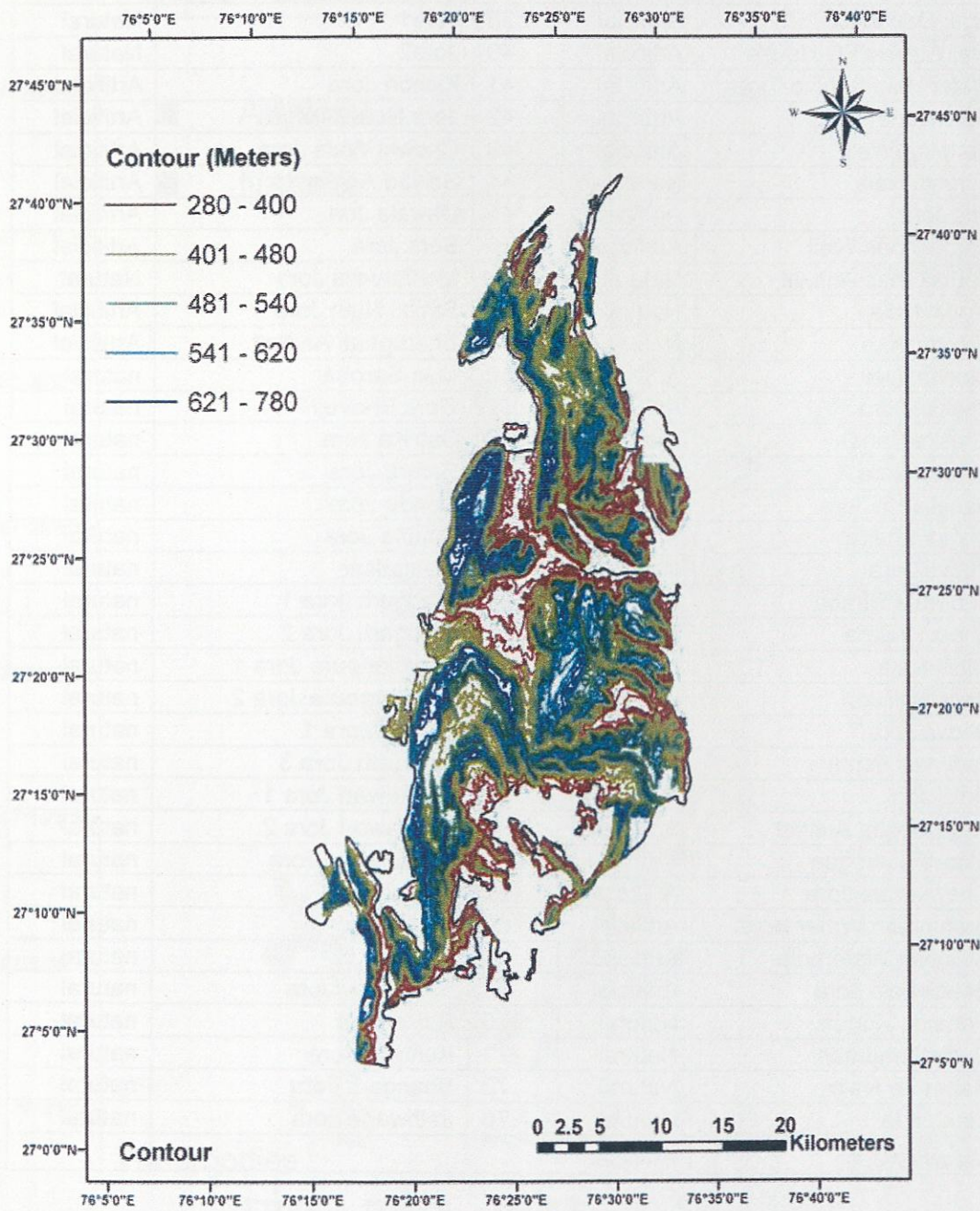




Figure 2. 8. Drainage map of Sariska Tiger Reserve

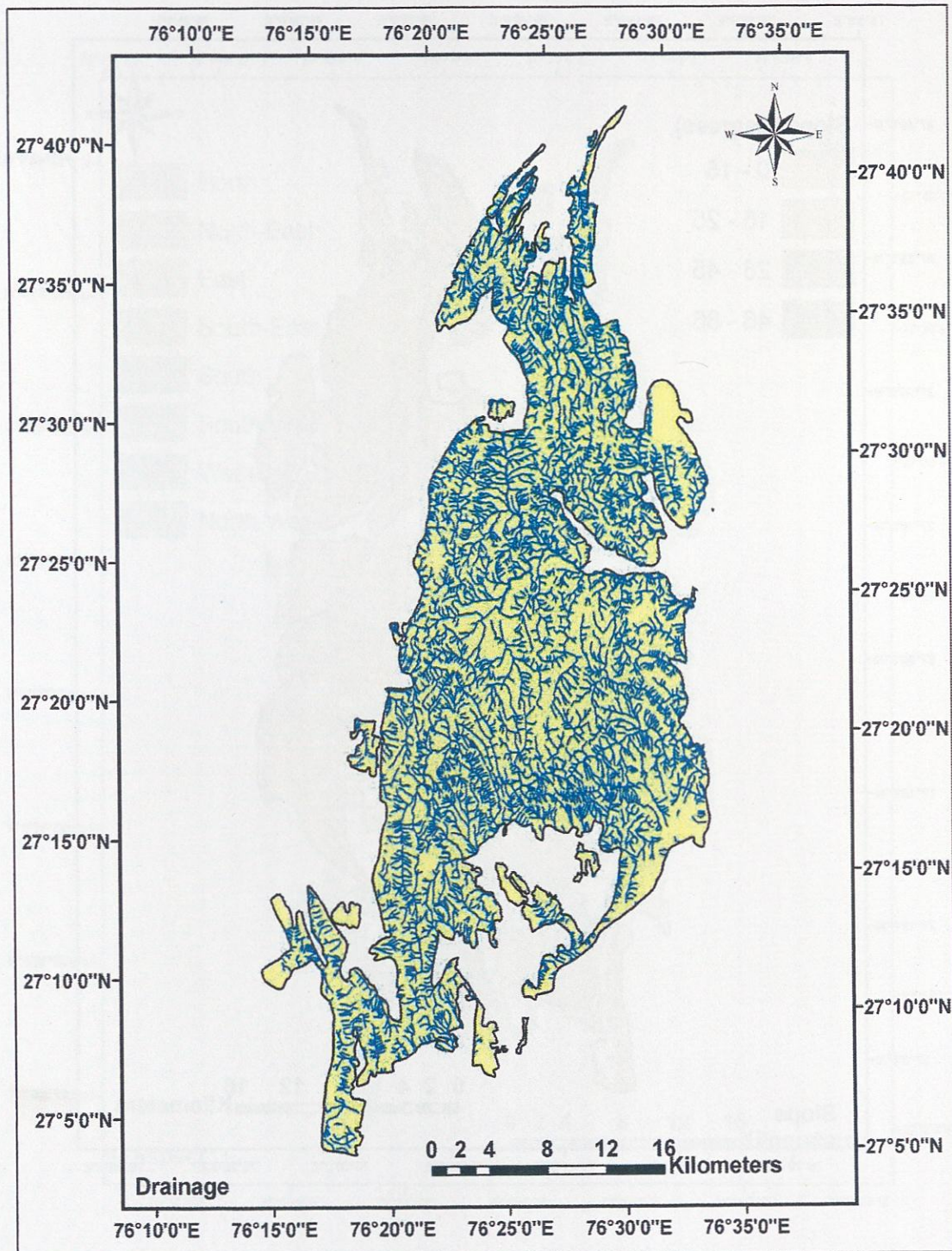




Figure 2. 9. Slope map of Sariska Tiger Reserve

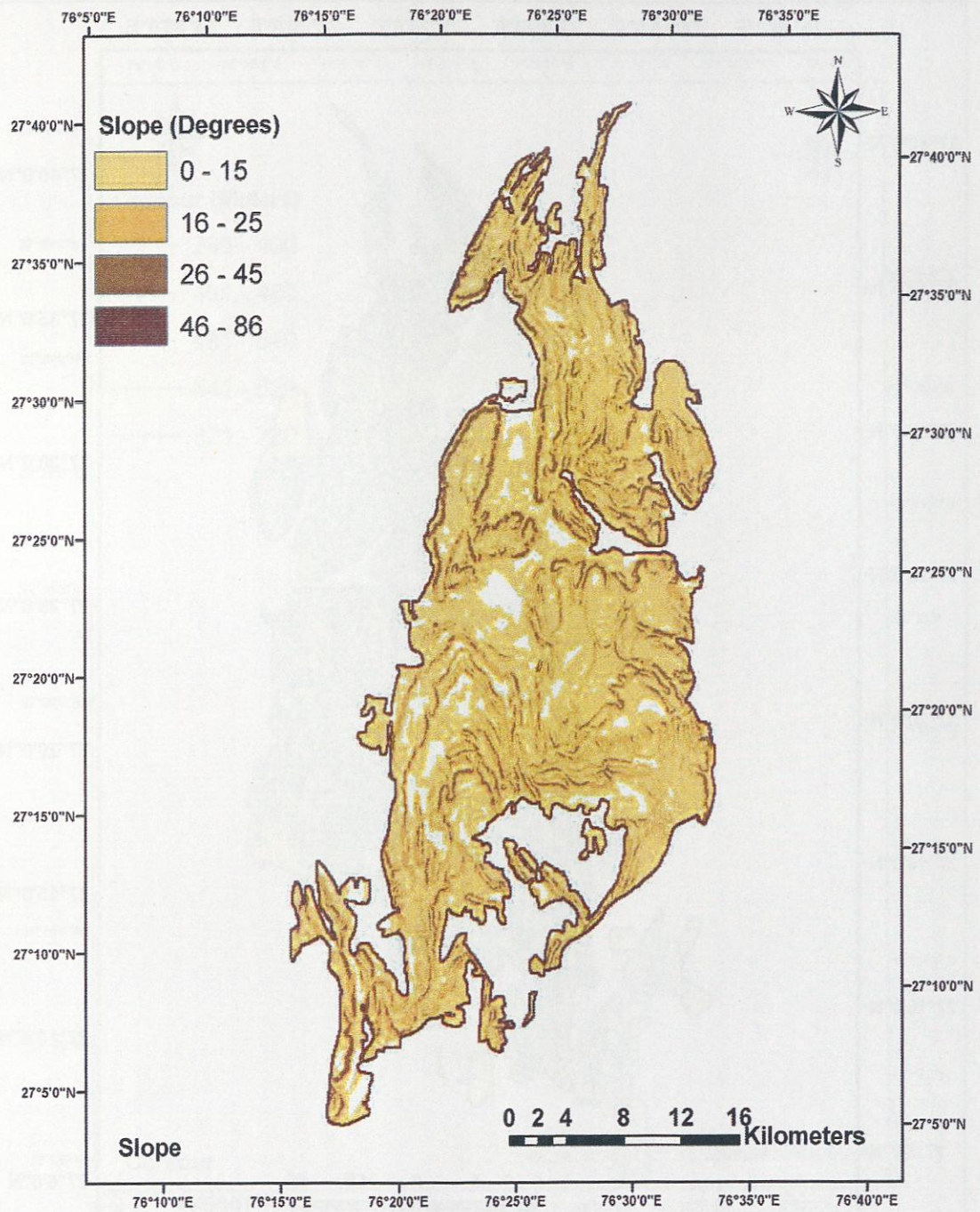




Figure 2. 10. Aspect map of Sariska Tiger Reserve

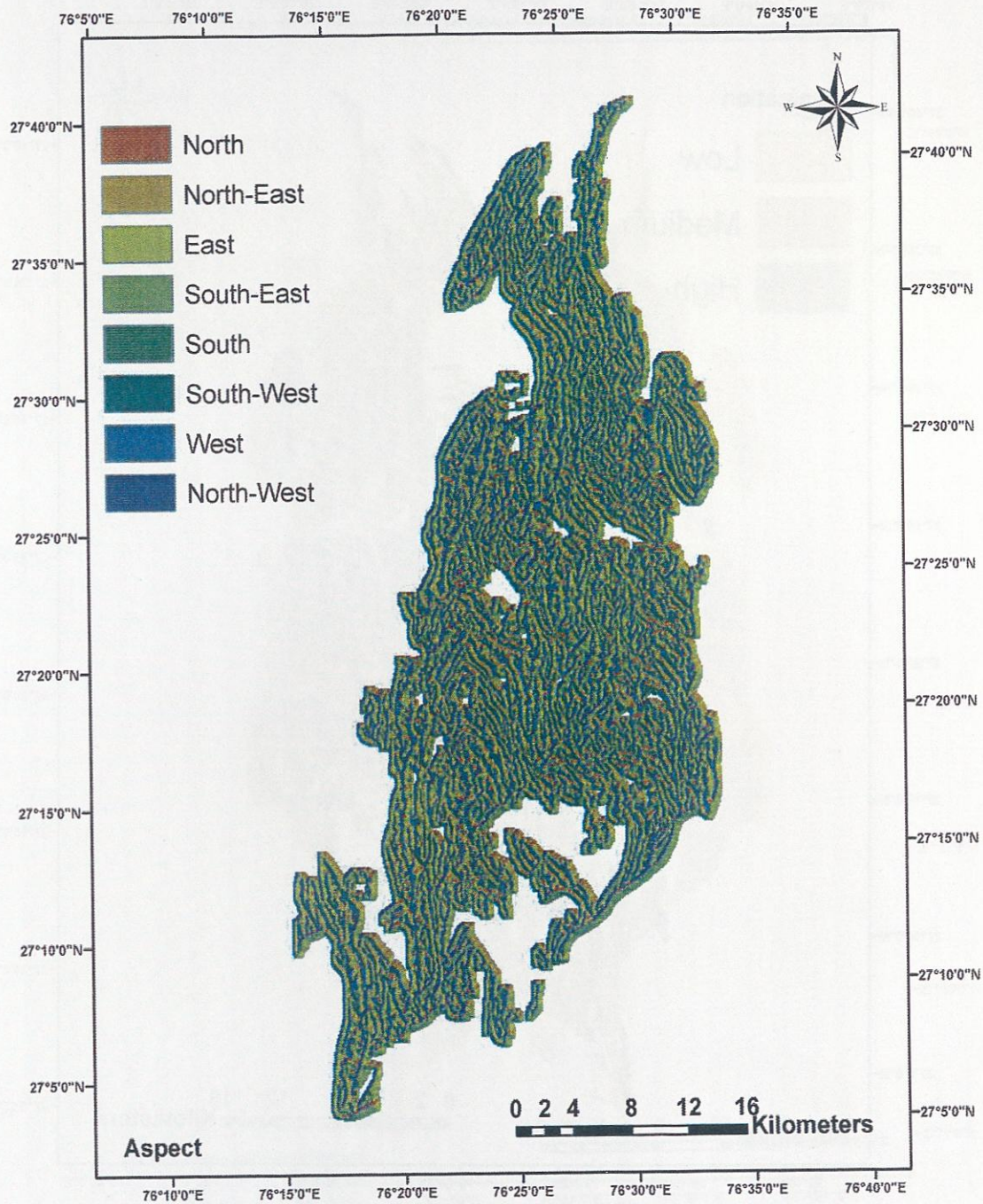




Figure 2. 11. Hill shade map of Sariska Tiger Reserve

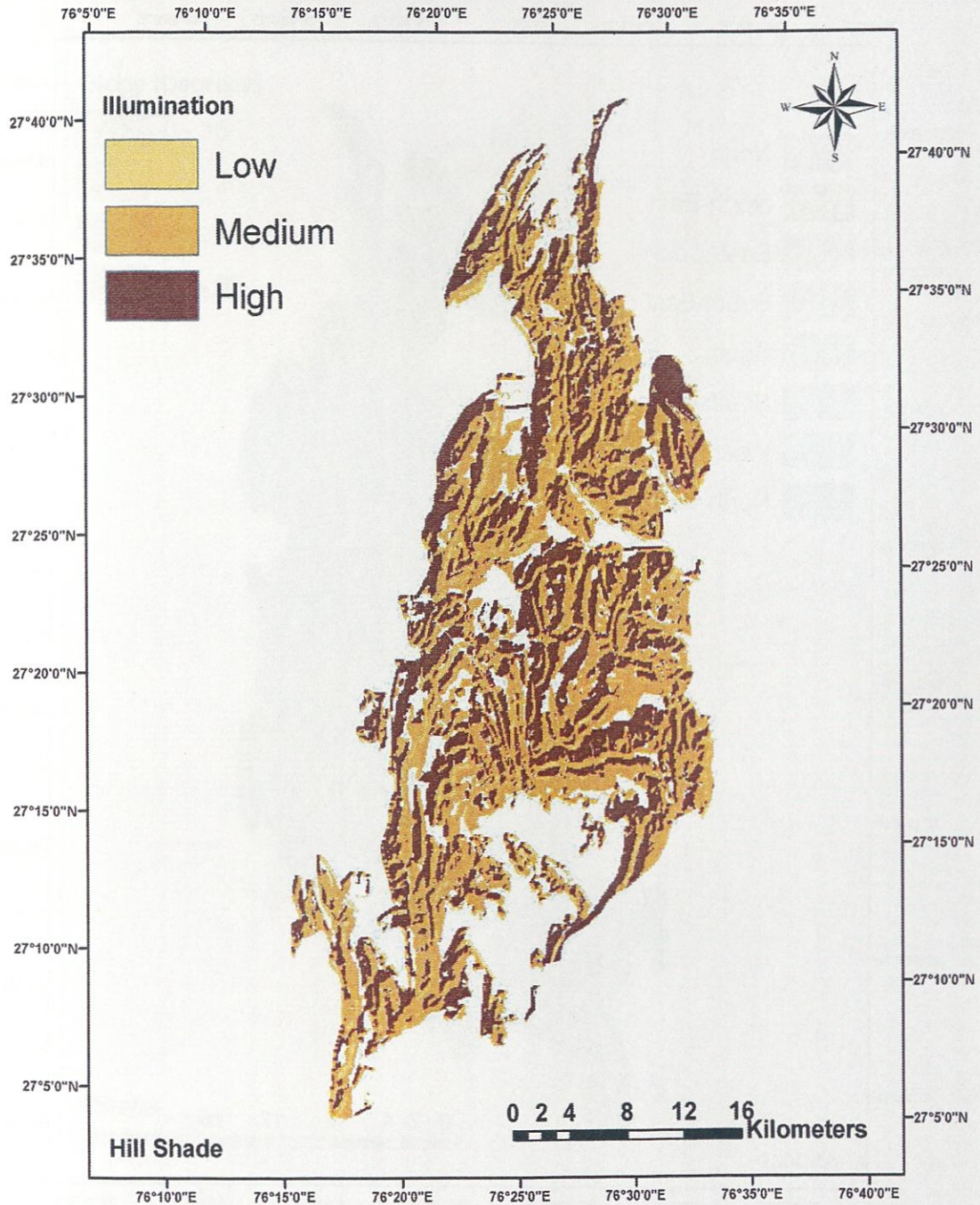




Figure 2. 12. Digital elevation model of Sariska Tiger Reserve

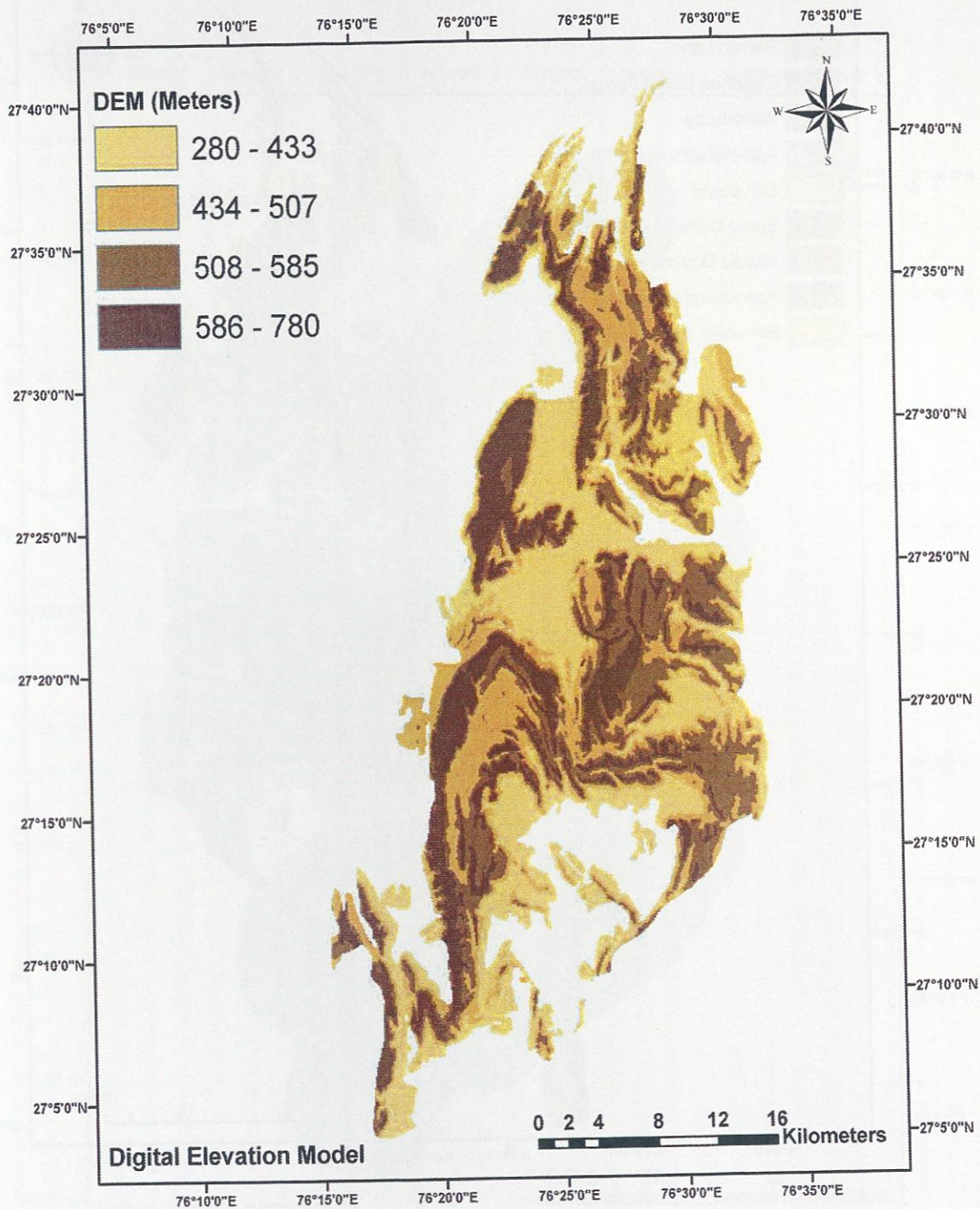
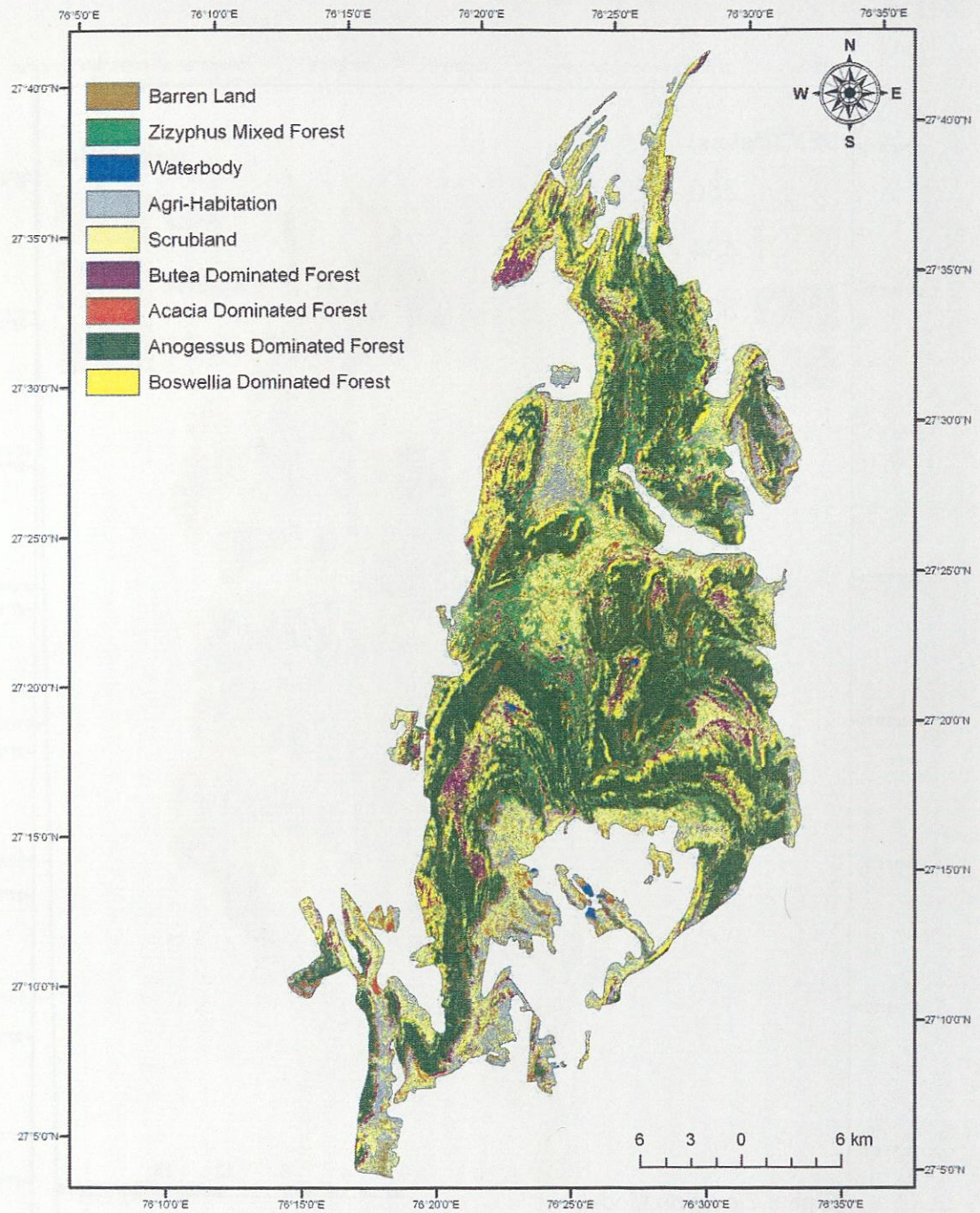


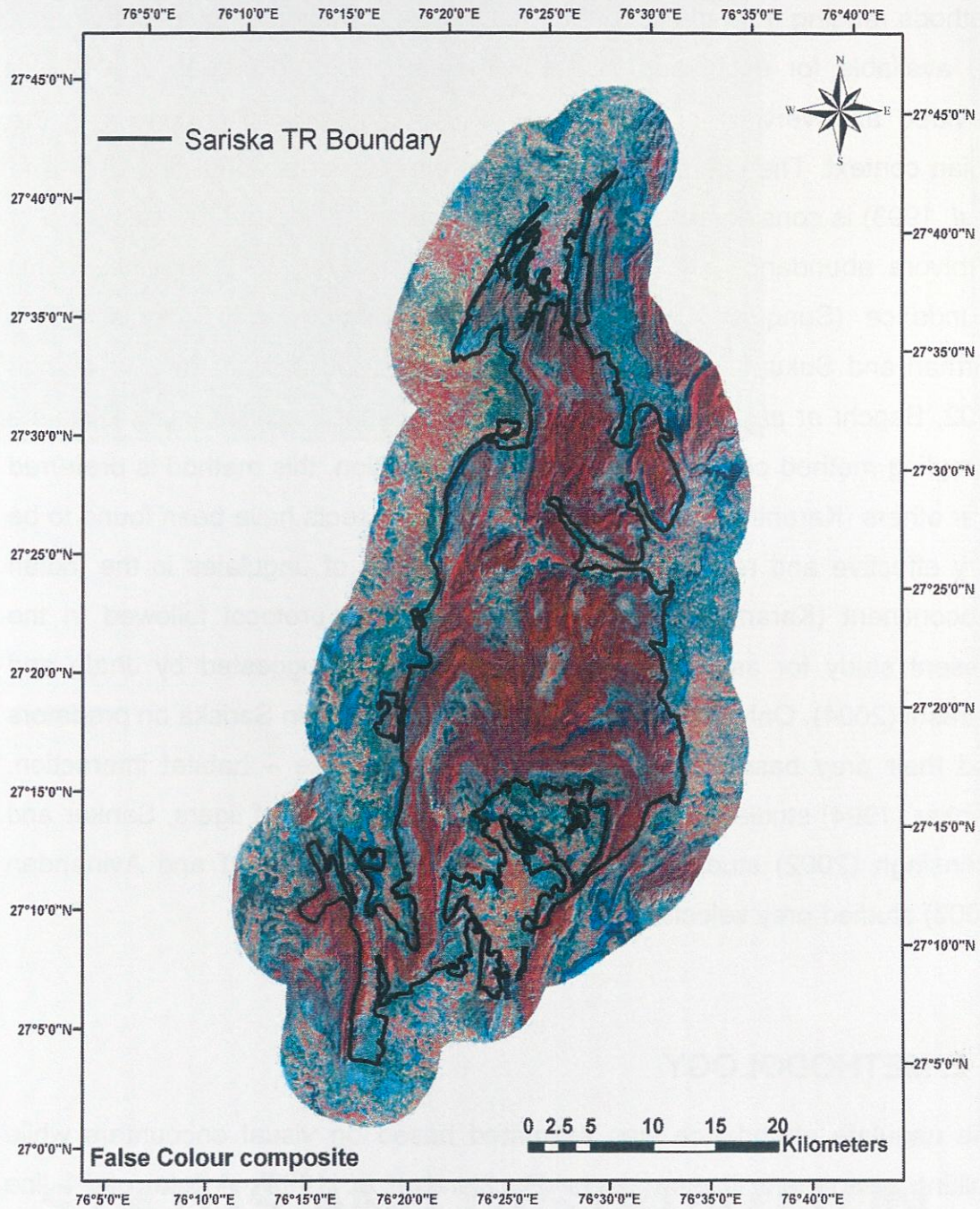


Figure 2. 13. Vegetation and land cover map of Sariska Tiger Reserve





**Figure 2. 14. False Color Composite map of Sariska Tiger Reserve and surrounding areas.**





### 3. STATUS AND DISTRIBUTION OF PREY SPECIES

#### 3. 1. INTRODUCTION

The ungulate population study was done as a resource base estimation for species focusing on conservation, the leopard and other large carnivores. Methods ranging from direct counts and indirect samplings (eg. pellet counts) are available for estimation of herbivore abundance. Rodgers (1991) has provided an overview of techniques for conducting wildlife census in the Indian context. The line transect method (Burnham *et al.* 1980 and Buckland *et al.* 1993) is considered to be the most appropriate method for estimation of herbivore abundance and has been used extensively to determine animal abundance (Sunquist 1981, Mathur 1991, Karanth and Sunquist 1995, Varman and Sukumar 1995, Biswas & Sankar 2002, Sankar and Johnsingh 2002, Bagchi *et al.* 2003). Since estimating animal densities using Distance Sampling method corrects the bias of non-detection, this method is preferred over others (Karanth and Nichols 1998). Line transects have been found to be very effective and reliable in estimating densities of ungulates in the Indian subcontinent (Karanth *et al.* 2004a). A simplified protocol followed in the present study for assessing the prey base is as suggested by Jhala and Qureshi (2004). Only few studies had been conducted in Sariska on predators and their prey base. Mathur (1991) studied ungulate – habitat interaction, Sankar (1994) studied prey abundance and food habits of tigers, Sankar and Johnsingh (2002) studied food habits of tiger and leopard and Avinandan (2003) studied prey selection by tigers in Sariska.

#### 3. 2. METHODOLOGY

The ungulate abundance was estimated based on visual encounters while walking permanent line transects (Buckland *et al.* 1993). A total of 71 line transects were laid for the study in 75 beats of Sariska Tiger Reserve (881 km<sup>2</sup>) and the length of the transects varied from 1.4 km. to 3.5 km. The starting and end point of all transects were recorded with the help of a Global



**STATUS AND DISTRIBUTION  
OF PREY SPECIES**

# STATUS AND

## INTRODUCTION

The study of the status and distribution of various species is a complex task that requires a thorough understanding of the environment and the organisms themselves. This report aims to provide a comprehensive overview of the current state of knowledge regarding the status and distribution of several key species in the region. The study was conducted over a period of six months, during which extensive fieldwork and laboratory analysis were carried out. The results of the study are presented in the following sections, which discuss the methodology used, the distribution patterns observed, and the implications of the findings for conservation and management.

## METHODOLOGY

The methodology employed in this study was a combination of field observations and laboratory analysis. Fieldwork was conducted in various habitats across the study area, with a focus on identifying and recording the presence and abundance of the target species. Laboratory analysis was used to confirm the identity of the species and to assess their genetic diversity. The data collected from the field and laboratory were then analyzed using statistical methods to determine the significance of the findings.

## RESULTS AND DISCUSSION

The results of the study indicate that the status and distribution of the target species are highly variable across the study area. The species were found to be most abundant in certain habitats, such as wetlands and riparian areas, and least abundant in others, such as upland forests. The distribution patterns observed suggest that the species are highly dependent on specific environmental conditions and resources. The findings of the study have important implications for the conservation and management of the species, and will be used to inform the development of a management plan for the region.



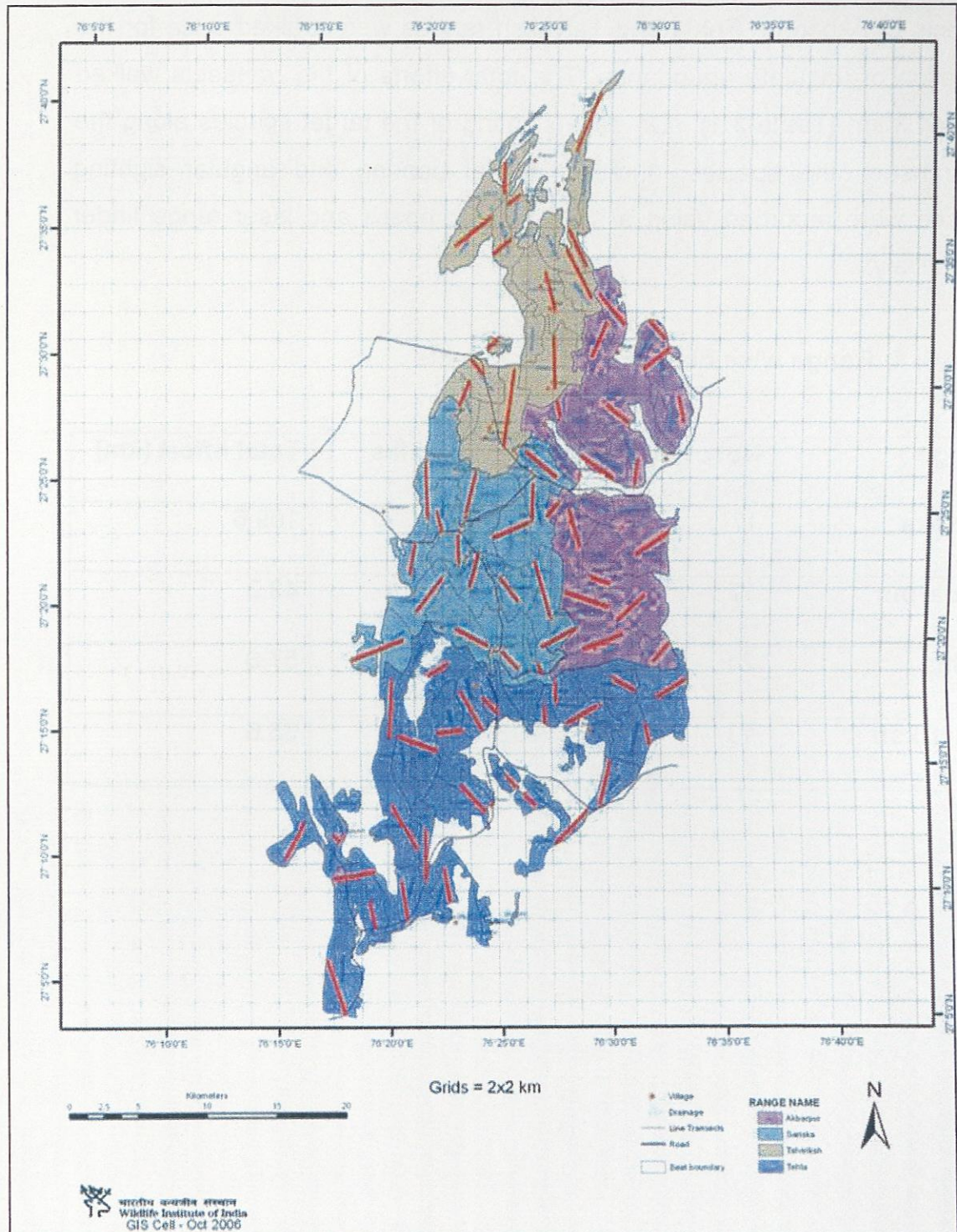
Positioning System. The period of study was between November 2006 and May 2007. Transects were walked early in the morning between 5:30 a.m. and 8:15 a.m. The transects of Sariska range were walked three times and transects of Akbarpur, Tehla and Talvriksh ranges were walked once for the estimation of ungulate abundance. The total efforts of the transects walked was 244.3 km (Table 3.1). On each sighting of the target species along the line transect, the species, number, animal bearing and angular sighting distance were recorded using a hand held compass and laser range finder respectively.

**Table 3. 1. Range wise details of line transects**

Range	No. of transects	No. of walks	Total effort (km)
Sariska	17	53	109.6
Akbarpur	17	17	43.3
Tehla	24	24	57.8
Talvriksh	13	13	33.6



Figure 3.1. Line transect locations on the beat map of Sariska Tiger Reserve



Analysis of the treated data was done using the software DISTANCE 5 (Laake *et al.* 1993).



In Akbarpur, Tehla and Talvriksh ranges, numbers of encounters of wild ungulates were very low. So we did pooled analysis for all species in every range. We pooled encounters of all the species and made one data layer i.e. species under observation layer. In this analysis, the efforts were same for all species. We got one analytical model and same effective strip width for all species in every range. The model was selected by program DISTANCE 5 based on minimum Akaike Information Criterion (AIC).

### 3. 3. RESULTS AND DISCUSSION

#### 3. 3. 1. Density estimation of prey species

Though a total of 14 prey species were detected on transects, density estimate, cluster size and group encounter rate for 10 potential prey species were computed (**table 3.2, figure 3.2**). Estimates of density could not be computed for the remaining four species due to very low sample size.

**Table 3. 2. Density, cluster size and group encounter rate of prey species in Sariska Tiger Reserve**

Species	No. of sightings	Cluster Size	SE	Group ER
Chital	32	8.09	2.16	0.13
Sambar	75	3.22	0.26	0.31
Nilgai	193	4.1	0.23	0.80
Wild pig	45	10.28	3.52	0.19
Peafowl	215	3.58	0.25	0.89
Buffalo	62	7.23	0.69	0.26
Cattle	64	7.7	0.72	0.28
Goats	80	30.85	1.59	0.34
Hare	24	2.25	0.56	0.10
Common langur	49	13.55	1.49	0.20

SE = Standard error

Group ER = Group encounter rate



Figure 3. 2. Densities of prey species in Sariska Tiger Reserve

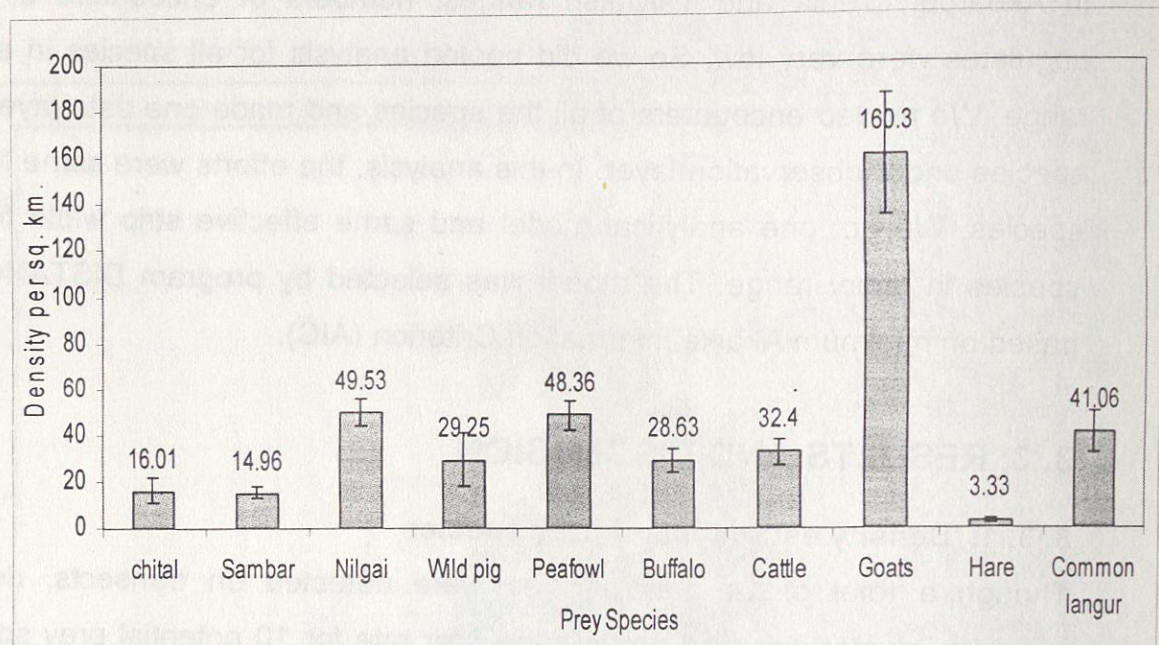


Table 3. 3. Percentage abundance of the major prey species in Sariska Tiger Reserve

Species	Density (no. of animals/km <sup>2</sup> )	Biomass / km <sup>2</sup>	% Abundance
Chital	16.01	821.31	3.78
Sambar	14.96	2030.52	3.53
Nilgai	49.53	9113.52	11.69
Wild pig	29.25	1111.50	6.90
Peafowl	48.36	164.42	11.41
Buffalo	28.63	7815.99	6.76
Cattle	32.4	5832.00	7.64
Goats	160.3	5129.60	37.82
Hare	3.33	11.99	0.79
Common langur	41.06	607.69	9.69



The densities and encounter rates of prey species are obtained from the analysis of program DISTANCE 5. The selected model is half normal with cosine adjustment term 3 based on minimum Akaike Information Criterion (AIC). The effective strip width for all species obtained was 33.12 meter. The encounter rate of each prey species is given in **figure 3.7 to 3.18**.

Nilgai was the most abundant wild ungulate prey species in Sariska Tiger Reserve (49.53 /km<sup>2</sup>) followed by wild pig (29.25), chital (16.01) and sambar (14.96). The common langur density in the study area was observed to be 41.06/km<sup>2</sup> which is the highest recorded wild prey species density in the study area. The recorded nilgai density in Sariska was higher than as reported from Pench (Biswas and Sankar 2002) and Gir (Khan *et al.* 1995). Nilgai was observed to be widely distributed across the entire study area. This could be attributed that dry deciduous forest and scrubland are more suitable to nilgai. The observed density of chital in Sariska was less than other protected dry deciduous areas in the subcontinent like Ranathambore (Karanth and Nichols 2000) and Gir (Khan *et al.* 1995). Chital was also the least widespread of the three large wild ungulates found in the study area. Chital had clumped distribution pattern, largely encountered in the valleys interspersed between the hills and in areas in the plains, which had good grass cover with least human disturbance. Sambar density in the study area (14.96/ km<sup>2</sup>) was higher than the density figures obtained for Ranathambore (Karanth and Nichols 1998), Gir (Khan *et al.* 1995), Panna (Chundawat 2001) and Kuno (Banerjee 2005). The observed density for wild pigs (29.25/km<sup>2</sup>) was higher than the recorded densities in previous study in Sariska i.e 17.5/km<sup>2</sup> (Avinandan 2003). Domestic cattle and domestic buffalo were found distributed in the entire study area.

The estimated density, cluster size and group encounter rate of different prey species in Sariska, Akbarpur, Tehla and Talviriksh ranges are given in **table 3.4, 3.5, 3.6 and 3.7** respectively.



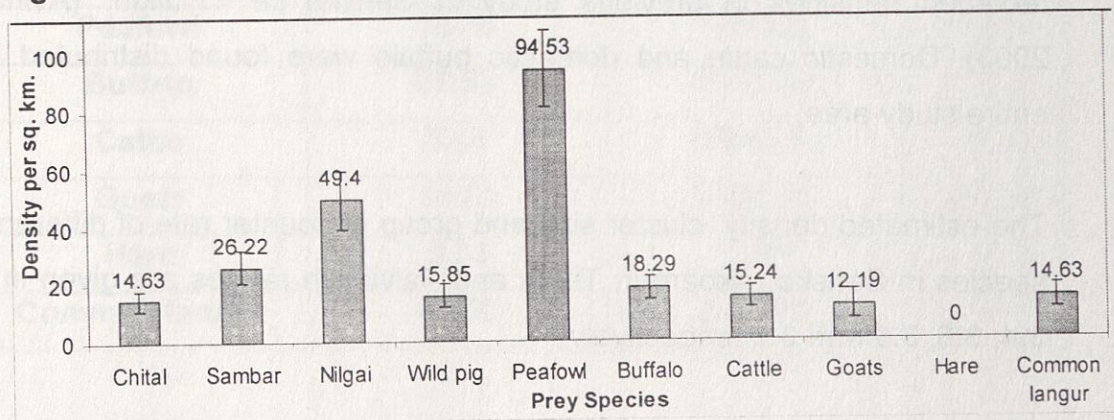
### 3. 3. 2. Estimation of density of prey species in Sariska Range of STR:

Nilgai was the most abundant wild ungulate prey species in Sariska Range ( $49.4 / \text{km}^2$ ) followed by sambar (26.2), wild pig (15.8) and chital (14.6) (table 3.4). The selected model is half normal with cosine adjustment term 3 based on minimum AIC. The effective strip width for all species obtained as 37.76 m. Sariska range is the least disturbed range amongst the four ranges. Only the Sariska range bears a good forest cover and higher densities of wild ungulates. The observed encounter rates of wild preys are high in Sariska range as compared domestic livestock.

Table 3. 4. Density, cluster size and group encounter rate of prey species in Sariska range

Species	No. of sightings	Cluster Size	SE	Group ER
Chital	24	3.83	0.80	0.22
Sambar	43	2.93	0.27	0.39
Nilgai	79	2.26	0.15	0.72
Wild pig	26	5.46	0.96	0.24
Peafowl	153	2.38	0.18	1.40
Buffalo	28	6.16	0.73	0.26
Cattle	22	4.92	0.93	0.20
Goats	16	29.80	4.04	0.15
Hare	NA	0	0	0
Common langur	24	11.04	2.45	0.22

Figure 3. 3. Densities of prey species in Sariska range





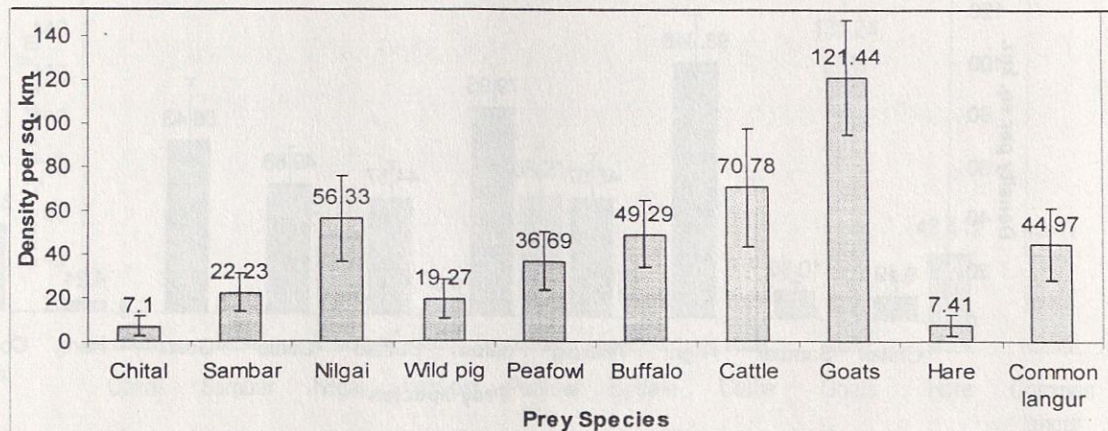
### 3. 3. 3. Estimation of density of prey species in Akbarpur Range of STR:

In Akbarpur Range, nilgai was the most abundant wild ungulate prey species (56.3/km<sup>2</sup>) followed by sambar (22.2), wild pig (19.2) and chital (7.1) (table 3.5). The selected model is half normal with cosine adjustment term 4 based on minimum AIC. The effective strip width for all species obtained as 35.50 m. Akbarpur range holds the maximum live stock densities in STR. The observed high density of sambar in this range may be attributed to the presence of hilly terrain with *Boswellia-Anogeissus* forests, which is a preferred habitat of sambar.

Table 3. 5. Density, cluster size and group encounter rate of prey species in Akbarpur range

Species	No. of sightings	Cluster Size	SE	Group ER
Chital	4	34.00	9.19	0.09
Sambar	13	4.61	0.99	0.30
Nilgai	28	5.42	0.96	0.65
Wild pig	5	10.00	2.35	0.12
Peafowl	16	6.00	1.16	0.37
Buffalo	14	9.50	2.31	0.32
Cattle	18	10.84	1.76	0.42
Goats	27	35.85	2.85	0.62
Hare	7	2.85	1.38	0.16
Common langur	10	17.20	2.41	0.05

Figure 3. 4. The densities of different prey species in Akbarpur range





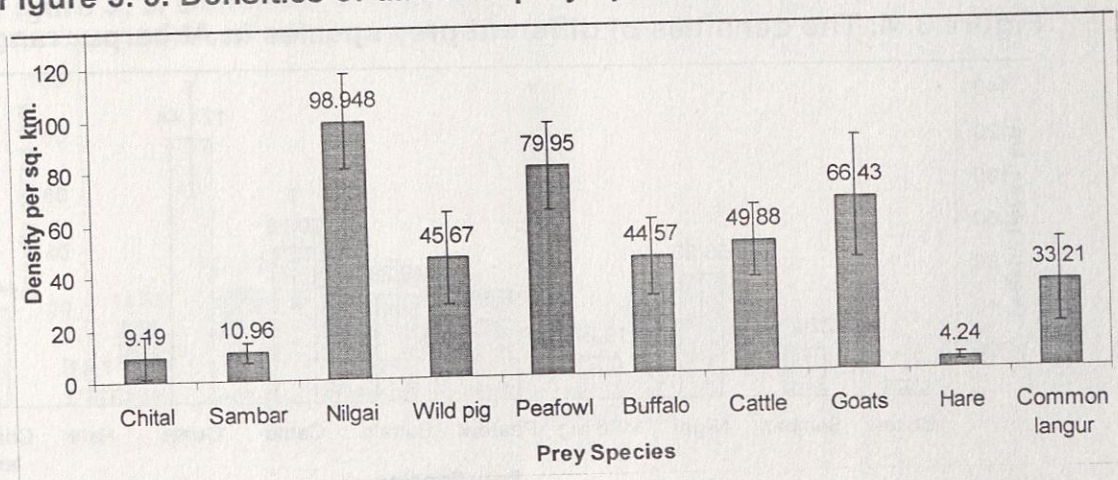
### 3.3.4. Estimation of density of prey species in Tehla Range of STR:

In Tehla Range, nilgai was the most abundant wild ungulate prey species ( $98.9/\text{km}^2$ ) followed by wild pig (45.6), sambar (10.9) and chital (9.1) (table 3.6). The selected model is half normal with cosine adjustment term 2 based on minimum AIC. The effective strip width for all species obtained as 23.60 meter. The observed nilgai density was the maximum in this range and this may be attributed to the presence of open forests.

Table 3. 6. Density, cluster size and group encounter rate of prey species in Tehla range

Species	No. of sightings	Cluster Size	SE	Group ER
Chital	3	8.66	4.70	0.05
Sambar	10	3.10	0.58	0.17
Nilgai	61	5.44	0.41	1.06
Wild pig	11	23.54	14.25	0.19
Peafowl	35	6.48	0.94	0.61
Buffalo	16	7.87	1.20	0.28
Cattle	16	8.81	1.17	0.28
Goats	16	33.93	3.17	0.28
Hare	10	1.20	0.13	0.17
Common langur	8	18.50	3.42	0.14

Figure 3. 5. Densities of different prey species in Tehla range





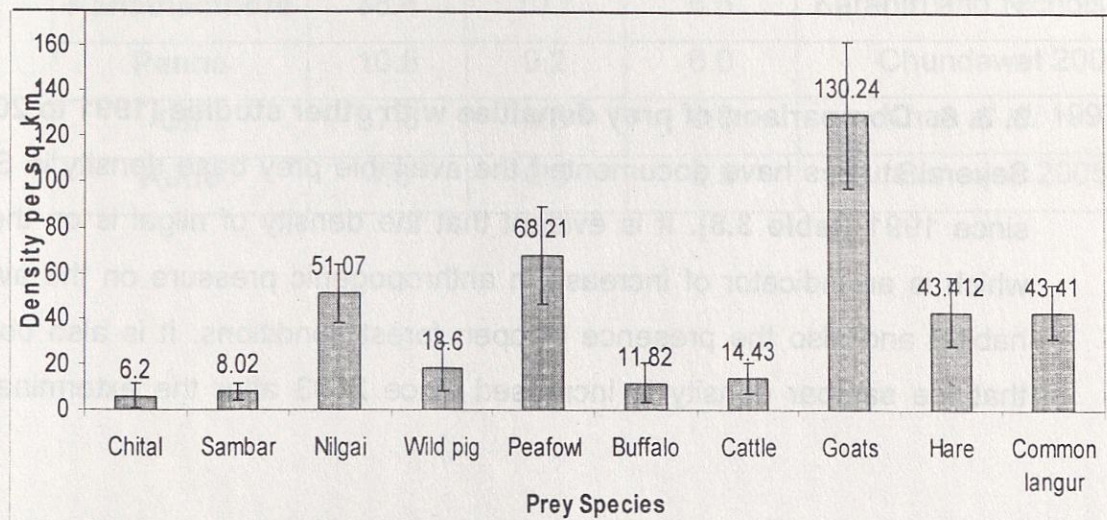
### 3. 3. 5. Estimation of density of prey species in Talvriksh Range of STR:

In Talvriksh Range, nilgai was the most abundant wild ungulate prey species (51.0/km<sup>2</sup>) followed by wild pig (18.6), sambar (8.0) and chital (6.2) (table 3.7). The selected model is Uniform with cosine adjustment 3 based on minimum AIC. The effective strip width for all species obtained as 27.31 meter. The observed densities of wild prey species were low in this range and this may be attributed to degraded habitat conditions.

Table 3. 7. Density, cluster size and group encounter rate of prey species in Talvriksh range

Species	No. of sightings	Cluster Size	SE	Group ER
Chital	1	5.00	0	0.03
Sambar	9	2.77	0.57	0.27
Nilgai	25	5.28	0.64	0.74
Wild pig	3	4.00	1.73	0.09
Peafowl	11	7.54	0.97	0.33
Buffalo	4	4.75	1.25	0.12
Cattle	8	6.75	1.09	0.24
Goats	21	23.09	1.78	0.63
Hare	7	3.14	1.33	0.21
Common langur	7	11.28	2.50	0.21

Figure 3. 6. Densities of prey species in Talvriksh range

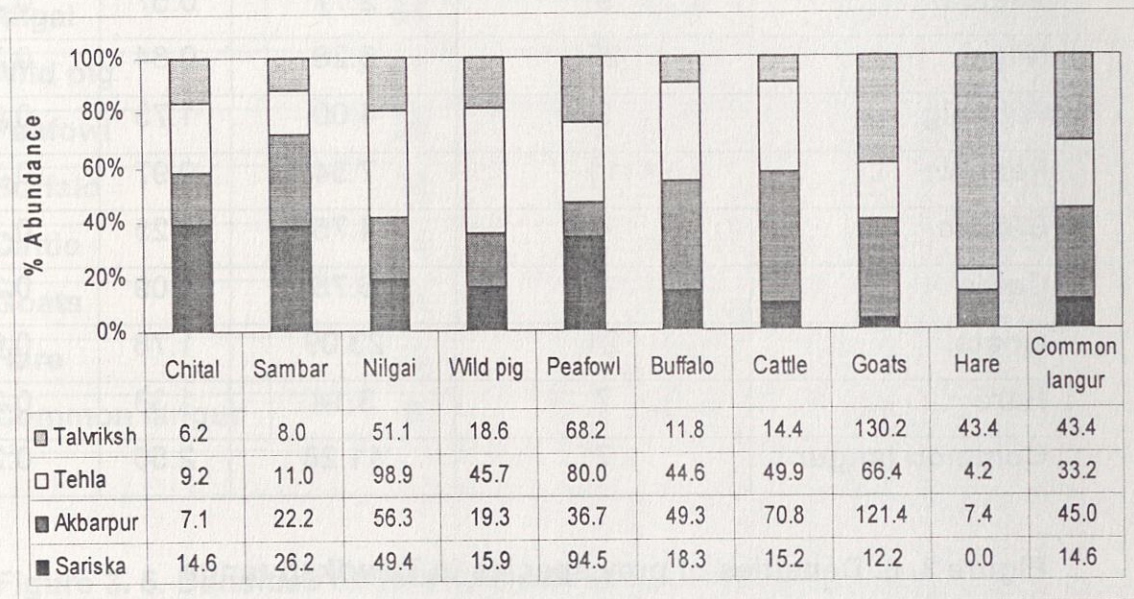




It is evident that the densities of wild prey species were the highest in Sariska range as compared to other ranges. Sariska range also holds least number of livestock (figure 3.8). Sariska is the only range with good forest cover and relatively less disturbed and it also falls in the center of the tiger reserve and the core zone-I (notified National Park). Of the two Cervids, sambar was the most widely distributed in the notified National Park area. This may be attributed to the fact that a large portion of the terrain is hilly and are relatively undisturbed.

The other three ranges had high livestock pressure and were reported low wild ungulate densities except for nilgai. Nilgai is abundant in all over the Tiger Reserve (Figure 3.8) and occupied valleys and open habitats.

**Figure 3. 7. Abundance of prey species in different ranges**



### 3. 3. 6. Comparison of prey densities with other studies (1991 to 2007)

Several studies have documented the available prey base density in Sariska since 1991 (table 3.8). It is evident that the density of nilgai is on the raise which is an indicator of increase in anthropogenic pressure on the available habitat and also the presence of open forest conditions. It is also observed that the sambar density is increased since 2003 after the extermination of



tigers from Sariska. The large bodied ungulates like sambar and nilgai are increasing in numbers because leopards avoid larger sized prey species.

**Table 3. 8. The wild ungulate densities (per km<sup>2</sup>) in Sariska Tiger Reserve (1991 to 2007).**

Studies	Chital*	Sambar*	Nilgai*	Wild pig*
Mathur (1991)	10.0	5.2	11.1	
Sankar (1994)	30.7	15	18.3	
Avinandan (2003)	27.6	8.4	5.2	17.5
Tiger Task Force (2005)	10.3	13.3	23.3	4.1
Present Study (2007)	16.0	15.0	49.5	29.3

\* densities per/km<sup>2</sup>

The reported wild ungulate species densities from various dry deciduous forest of the country are given in **table 3.9**. It is evident that in spite of severe anthropogenic pressure, the Core Zone-I of Sariska Tiger Reserve harbors comparable wild ungulate prey base densities (chital, sambar, nilgai, wild pig) with other dry deciduous areas.

**Table 3. 9. Wild ungulate densities reported (1997 to 2007) from various deciduous forests of the country**

Location	Chital	Sambar	Nilgai	Author
Present Study	16.0	14.9	49.5	Sankar <i>et al.</i> 2007
Ranathambore	38.4	10.7	6.6	Karanth and Nichols 2000
Panna	10.8	9.2	6.0	Chundawat 2001
Gir	57.3	3.5	0.6	Khan <i>et al.</i> 1997
Kuno	4.6	0.3	3.9	Banerjee 2005



Figure 3. 8. Beat wise encounter rate of chital

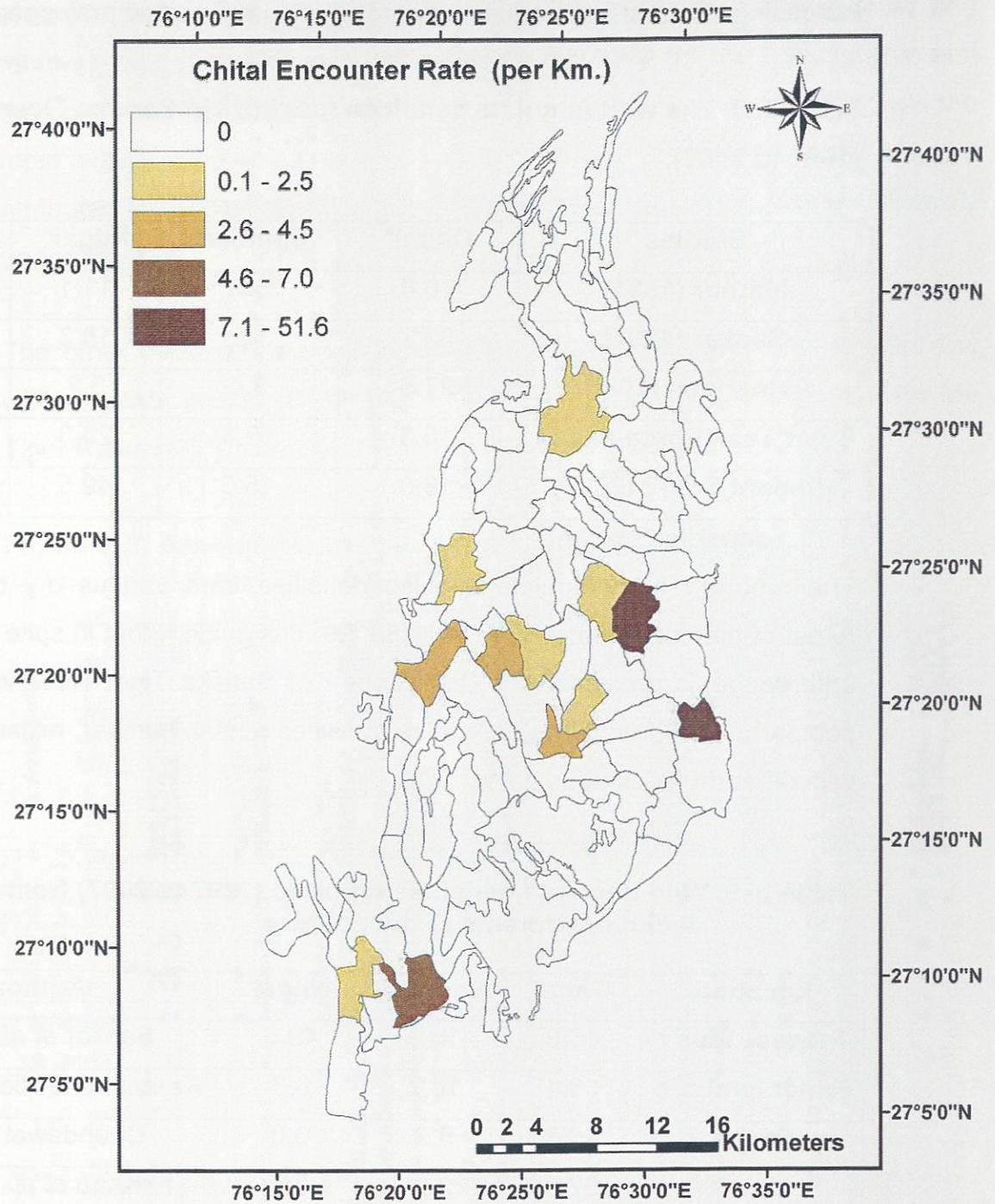




Figure 3. 9. Beat wise encounter rate of sambar

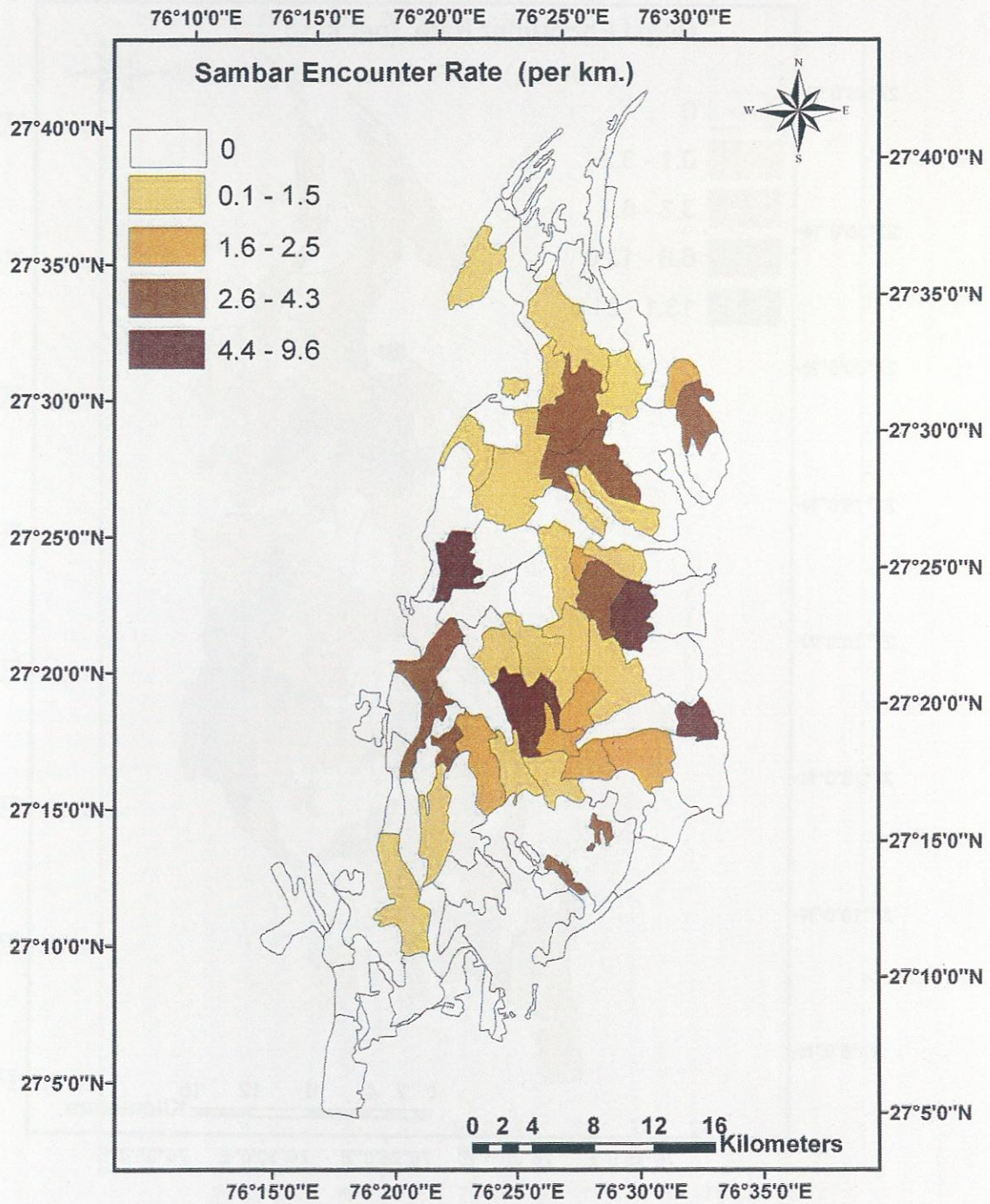




Figure 3. 10. Beat wise encounter rate of nilgai

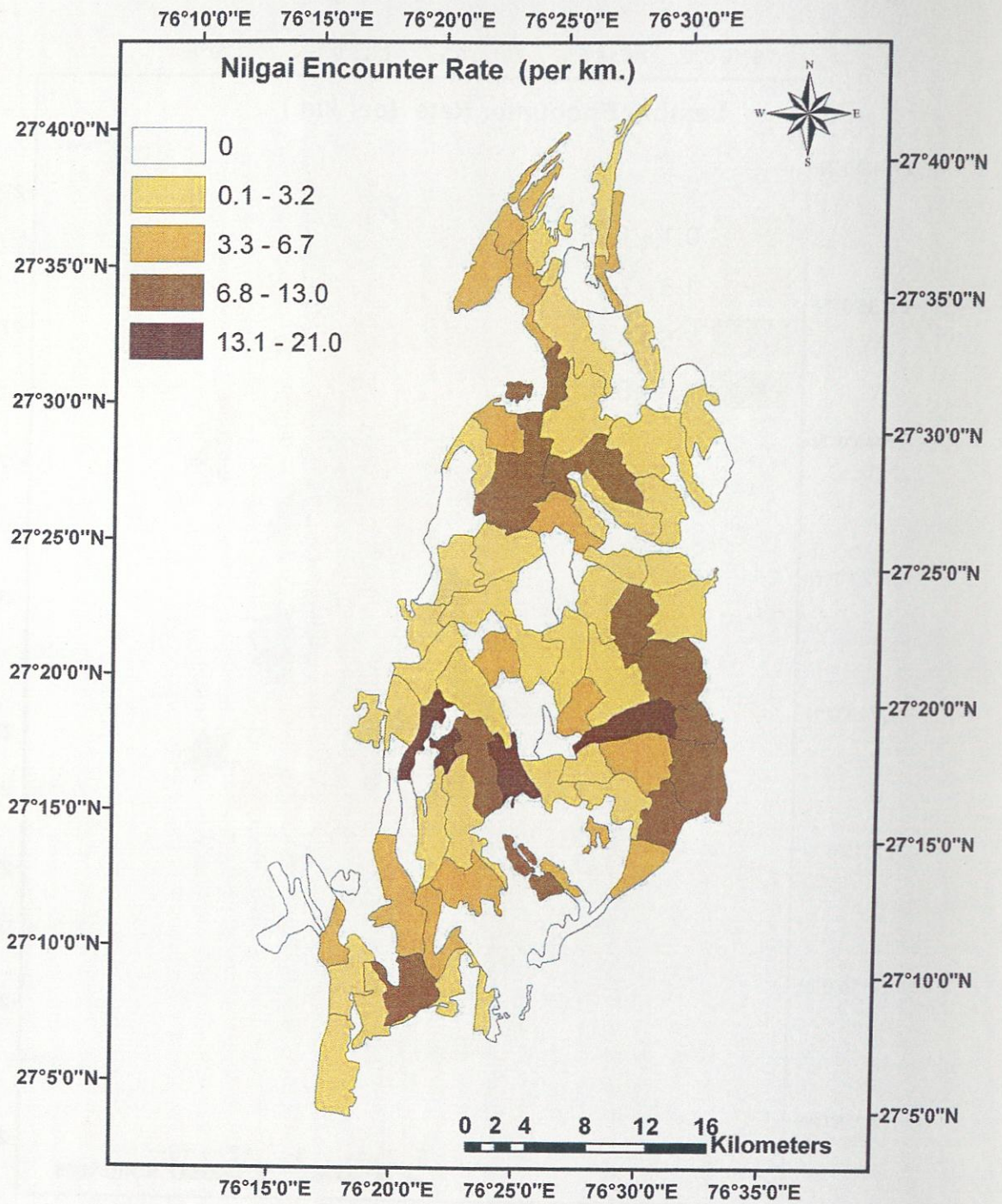




Figure 3. 11. Beat wise encounter rate of wild pig

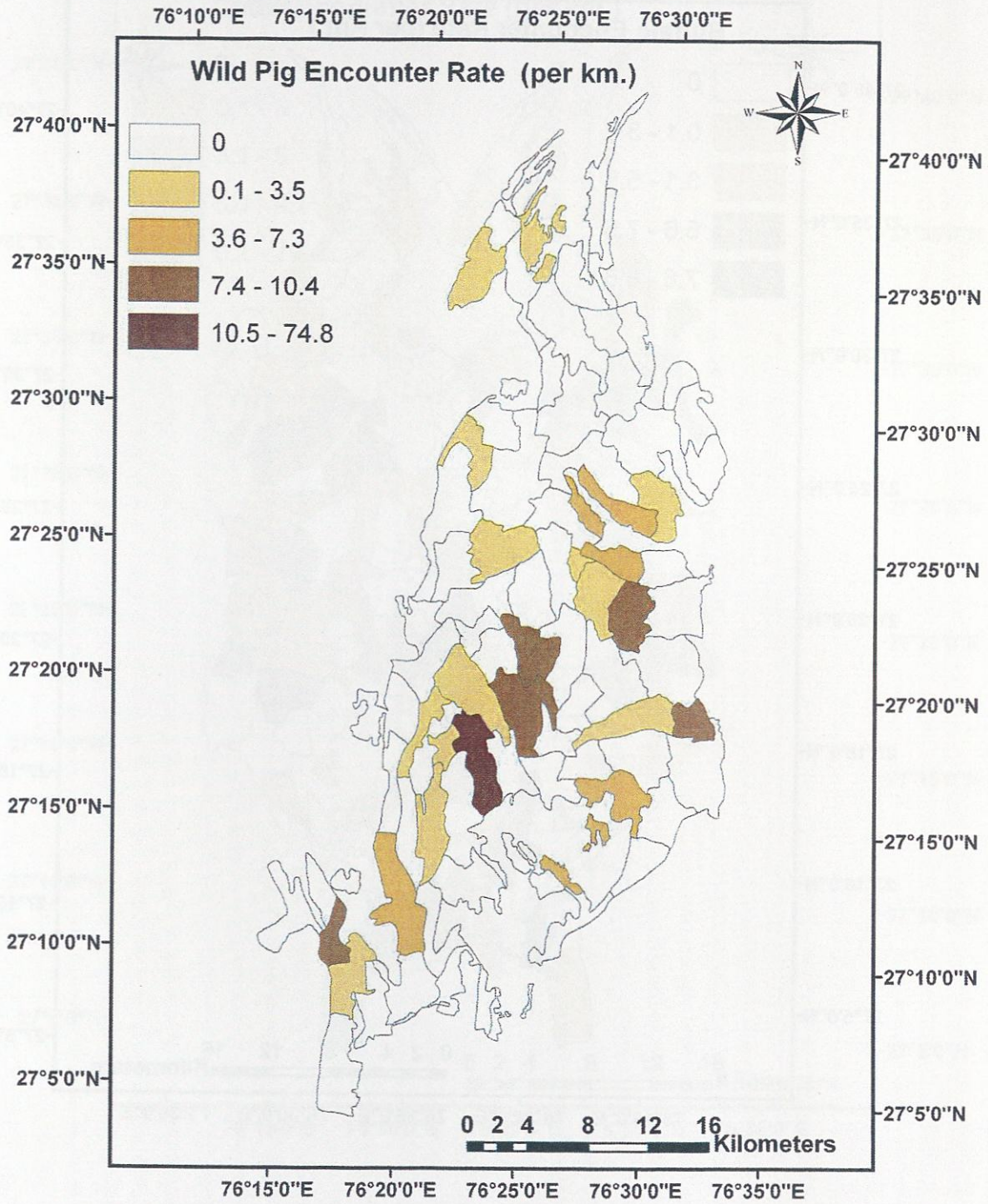




Figure 3. 12. Beat wise encounter rate of buffalo

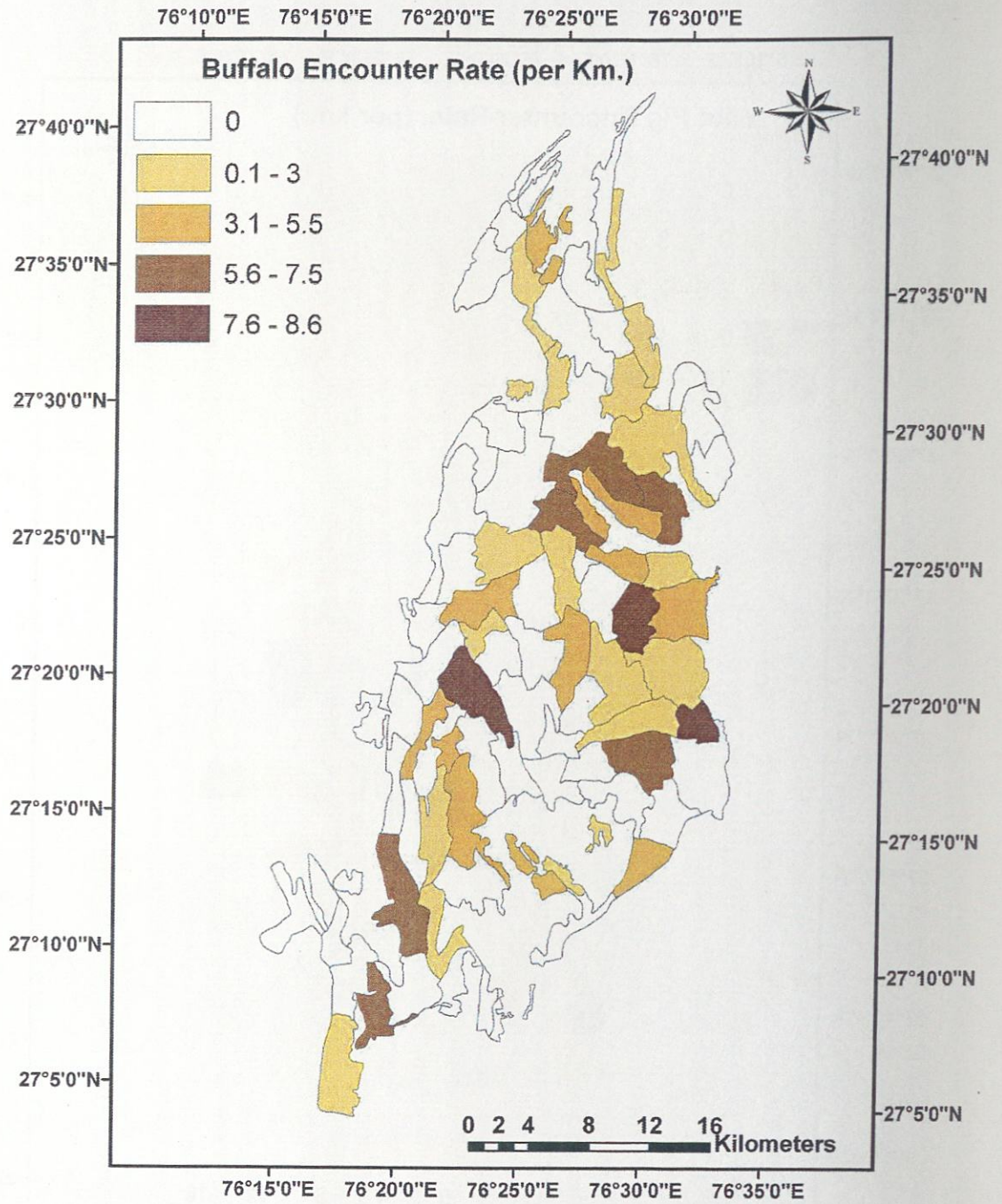




Figure 3. 13. Beat wise encounter rate of cattle

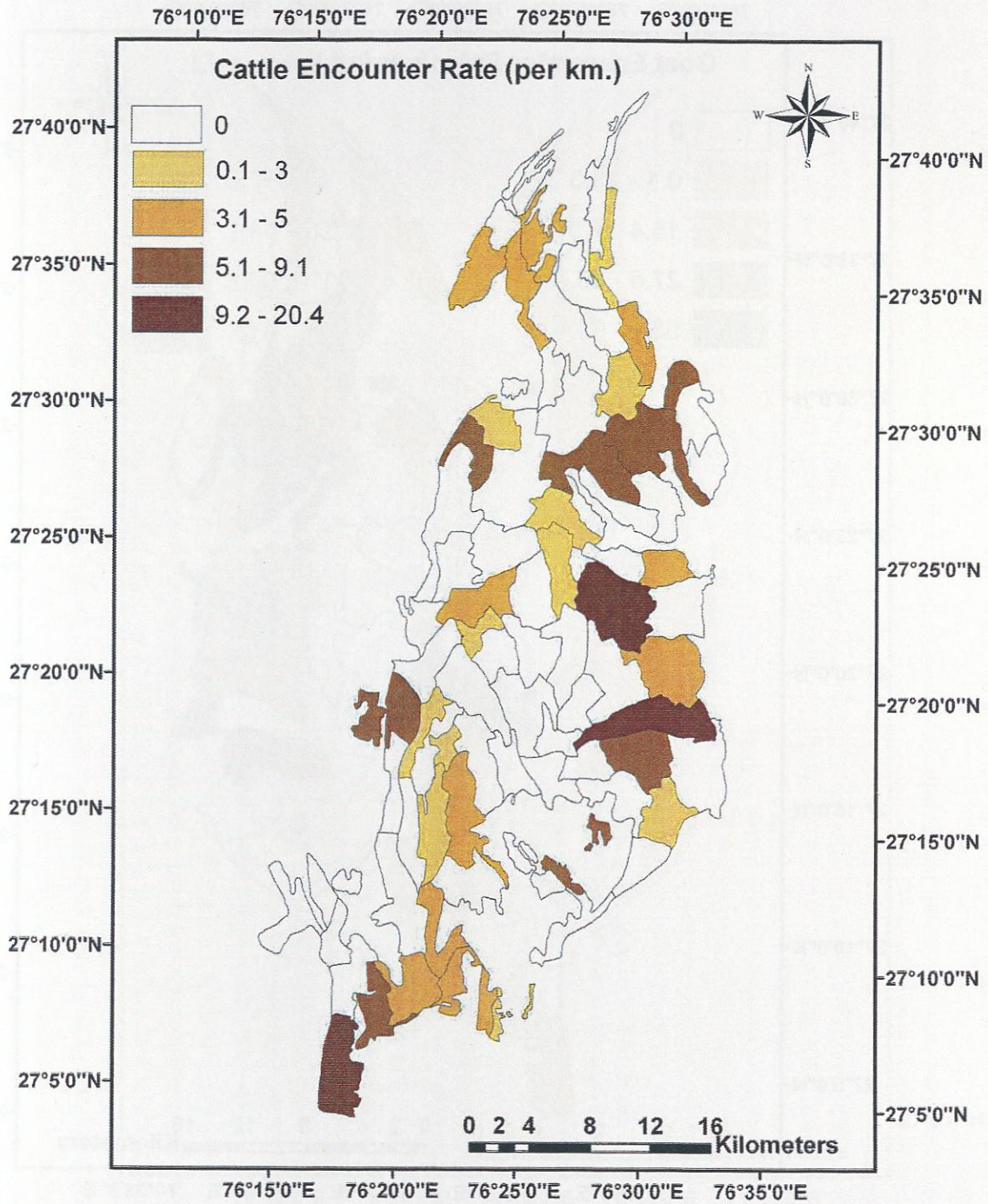




Figure 3. 14. Beat wise encounter rate of goats

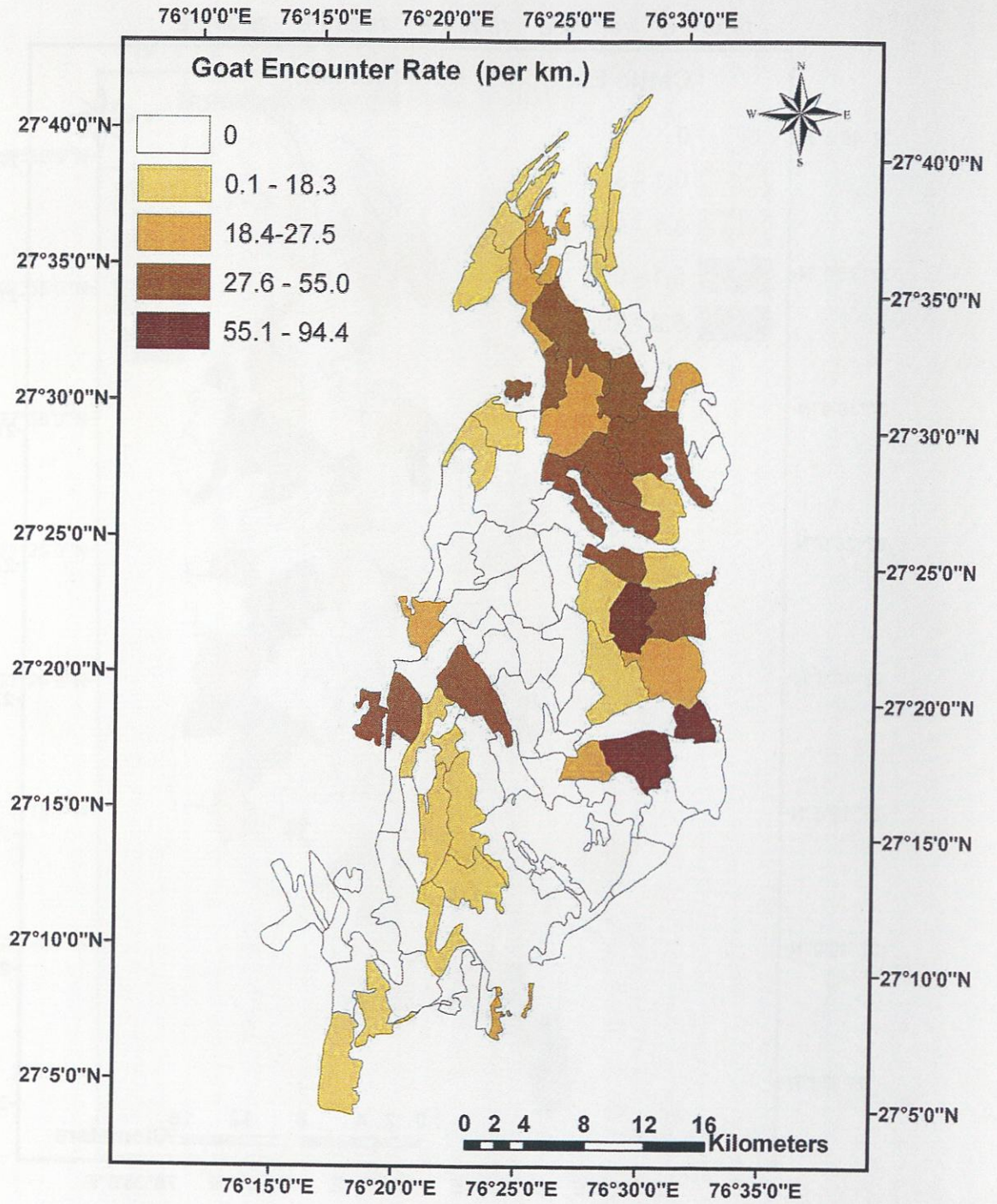




Figure 3. 15. Beat wise encounter rate of livestock (goat, cattle & buffalo)

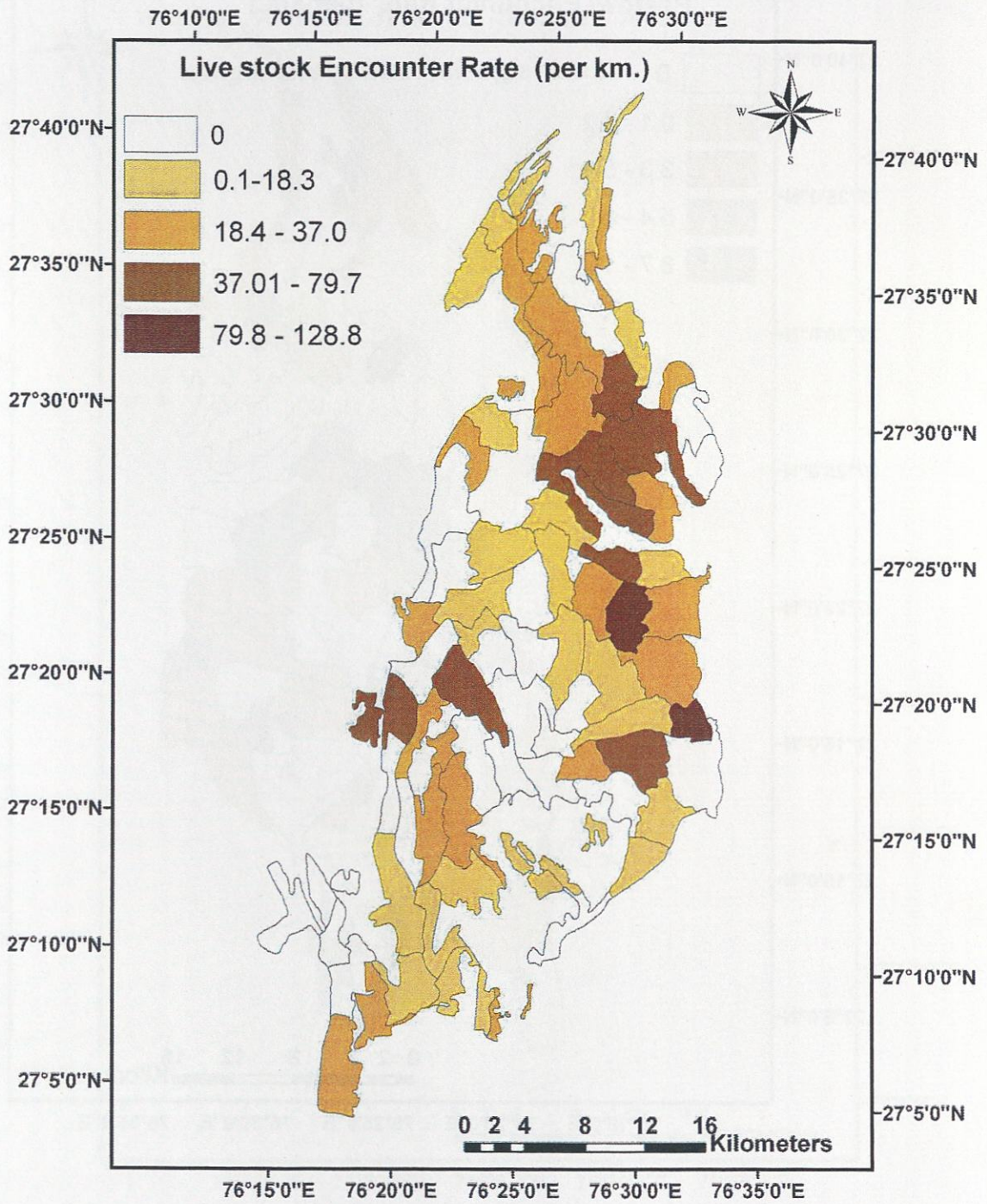




Figure 3. 16. Beat wise encounter rate of peafowl

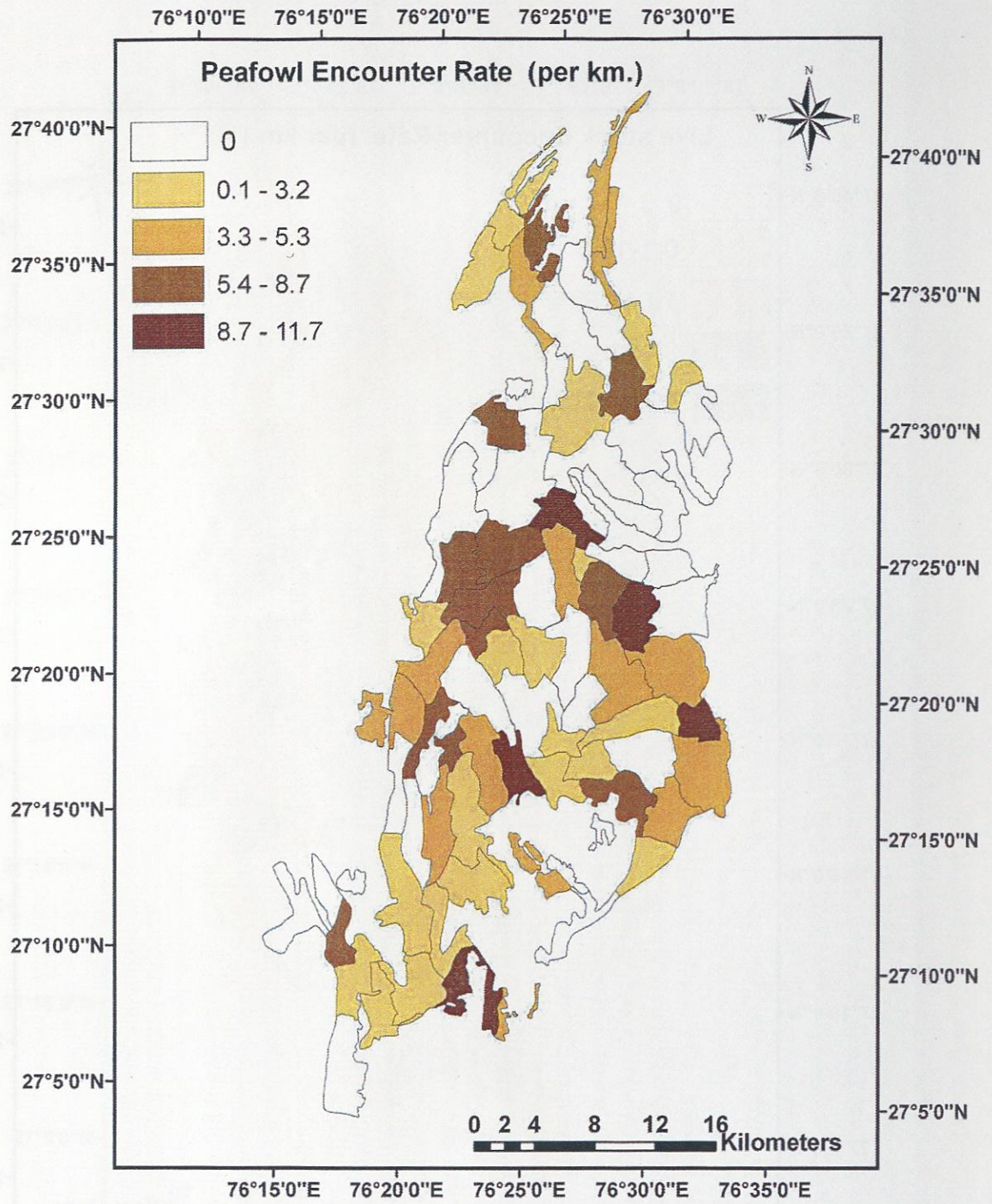
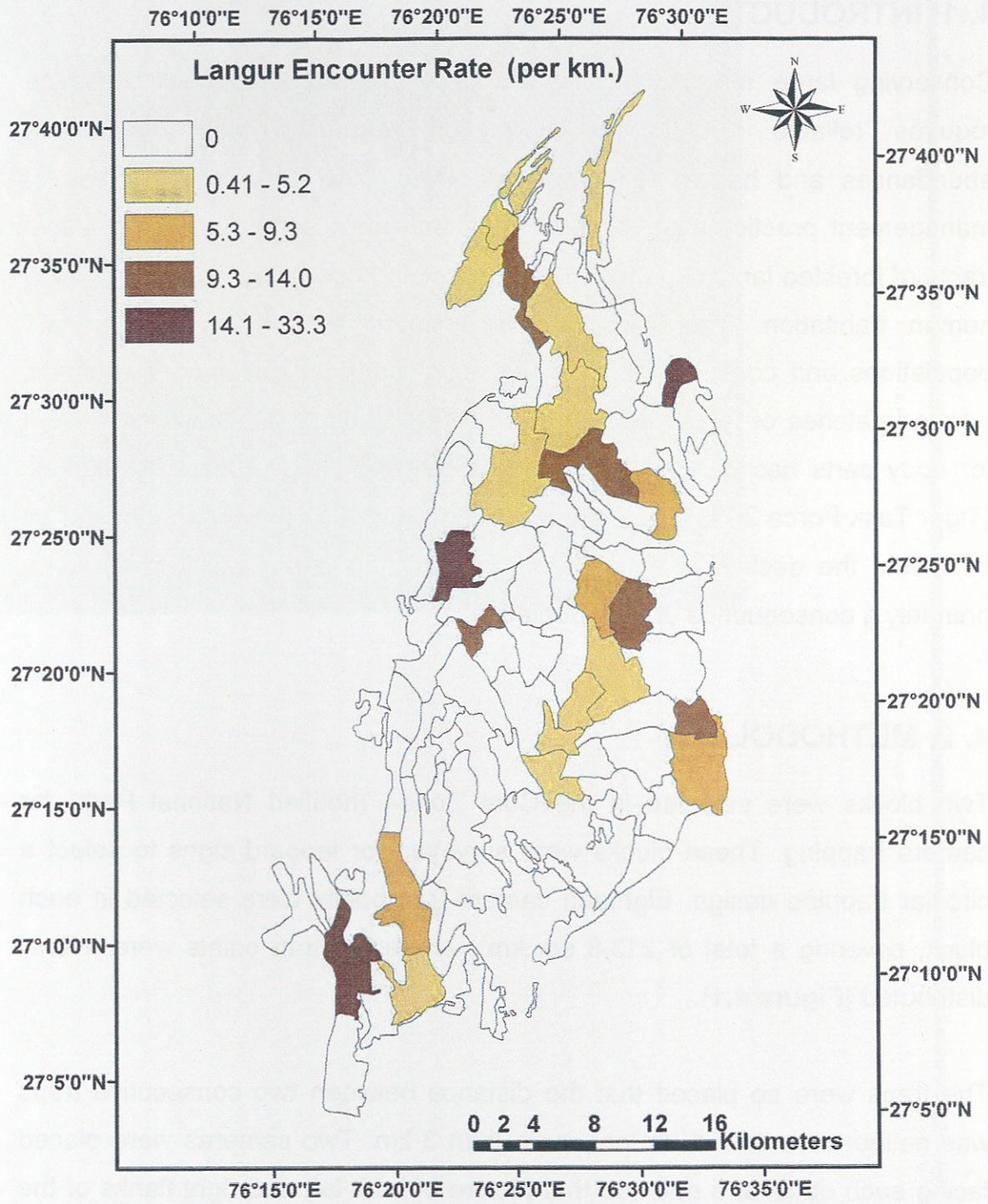




Figure 3. 17. Beat wise encounter rate of common langur



## 4. STATUS AND DISTRIBUTION OF LEOPARD AND OTHER CARNIVORES

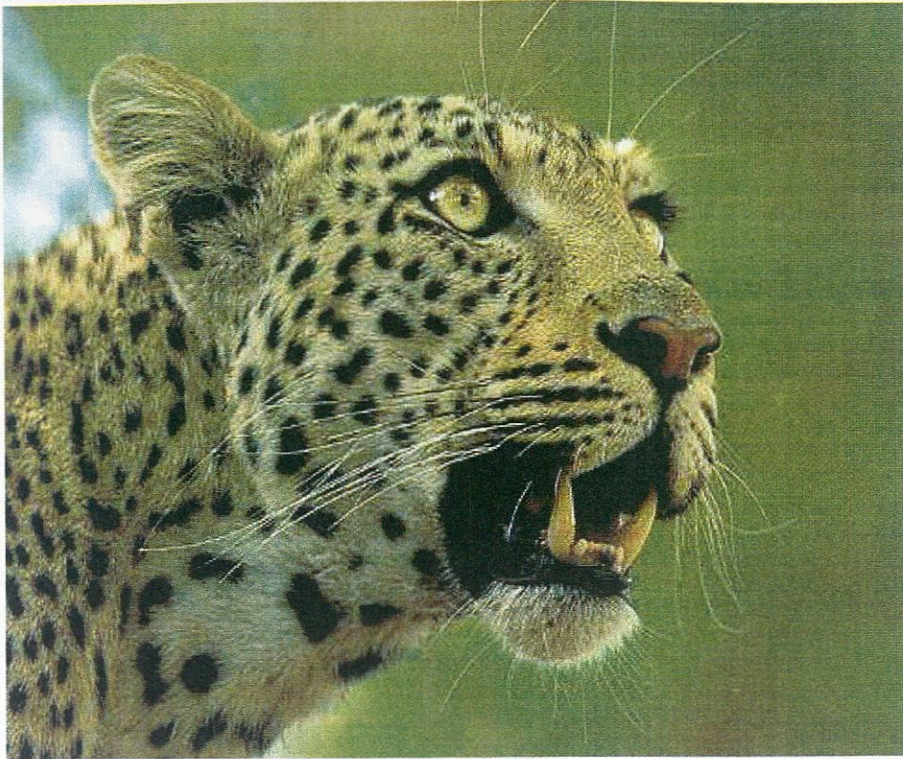
### 4. 1. INTRODUCTION

Conserving large mammalian species in a human dominated landscape requires reliable quantitative information regarding their distribution, abundances and habitat requirements. Using which, the effectiveness of management practices can be assessed and goals set for the future. Vast tracts of forested landscape that once housed the tiger have now been lost to human habitation. This has caused a sharp decline in the ungulate populations and confined many of the remaining tiger populations to small, isolated patches of forests (Smith *et al.* 1989). Though illegal killing of tigers for body parts has contributed greatly to the extinction of local populations (Tiger Task Force 2005), Karanth and Sunquist (2000) showed that based on field data the decline in tiger populations in their entire existing ranges is primarily a consequence of prey depletion.

### 4. 2. METHODOLOGY

Two blocks were selected in the Core Zone-I (notified National Park) for camera trapping. These blocks were surveyed for leopard signs to select a circular trapping design. Eighteen camera trap points were selected in each block, covering a total of 213.8 sq. km., where the trap points were evenly distributed (**Figure 4.1**).

The traps were so placed that the distance between two consecutive traps was neither less than 1 km nor more than 3 km. Two cameras were placed facing each other at a point so that picture of both left and right flanks of the leopard could be obtained. The units were placed at 20 to 25 cm height from the ground so as to target flanks of the leopard as well as the other lesser carnivores. The cameras were deployed properly at minimum 3 to 3.5 m from the centre of the trail so as to get a full frame picture of the leopard. The date and time format of each camera were properly set and the cameras



**STATUS AND DISTRIBUTION OF  
LEOPARD AND OTHER  
CARNIVORES**

4

Faint, illegible text, possibly bleed-through from the reverse side of the page.





were properly camouflaged. Minimum disturbance were made at the site where the cameras were deployed. The camera trap units were checked everyday to see that all the units are functioning properly, the cameras had rolls to spare, the batteries in the units were not exhausted etc. Each location and film roll were given a unique ID so that they could be properly recognized after developing and printing as the locations of captures were very important for density determination.

The unique spot pattern of the leopard makes it possible to differentiate between individuals from their photographs. The identification of the individuals were done in field and the capture history was prepared, which is actually the record of every individual leopard and provides valuable information about when and at which place a particular leopard was captured. The cameras were deployed at 15 locations in each sector and were monitored continuously.

In total 67 days were spent in camera trapping from January 2007 to March 2007, in two sampling blocks The total sampling effort amounted to 896 trap nights. The software program 'CAPTURE' (Otis *et al.* 1978, Nichols 1992) and DENSITY 3.3 (Efford *et al.* 2004) were used to analyze the data.

The following models (Otis *et al.* 1978, Nichols 1992) incorporated in the program CAPTURE, were considered in the analysis:

**Mo:** Capture probability is same for all the leopards and is not influenced by behavioral response, time or heterogeneity.

**Mh:** Capture probabilities were heterogeneous for each individual leopard, but not affected by trap response or time.

**Mb:** Capture probabilities differ between previously capture and uncaptured leopards due to trap response behavior, but are not influenced by heterogeneity or time.

**Mt:** Capture probability is the same for all individual leopards, but varies during sampling only due to time specific factors.



Figure 4. 1. Camera trap locations in Sariska Tiger Reserve on Google earth imagery

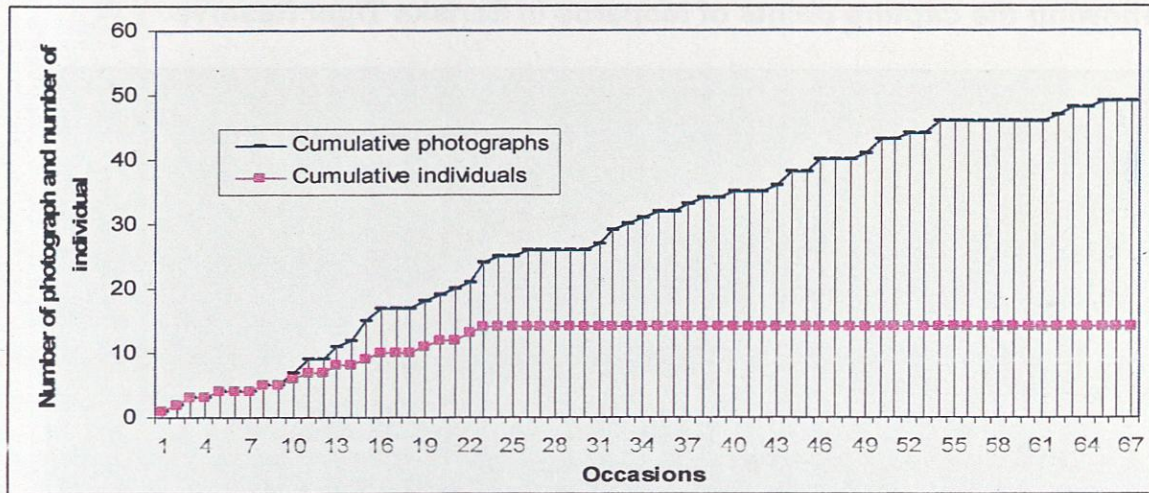




### 4. 3. RESULTS AND DISCUSSION

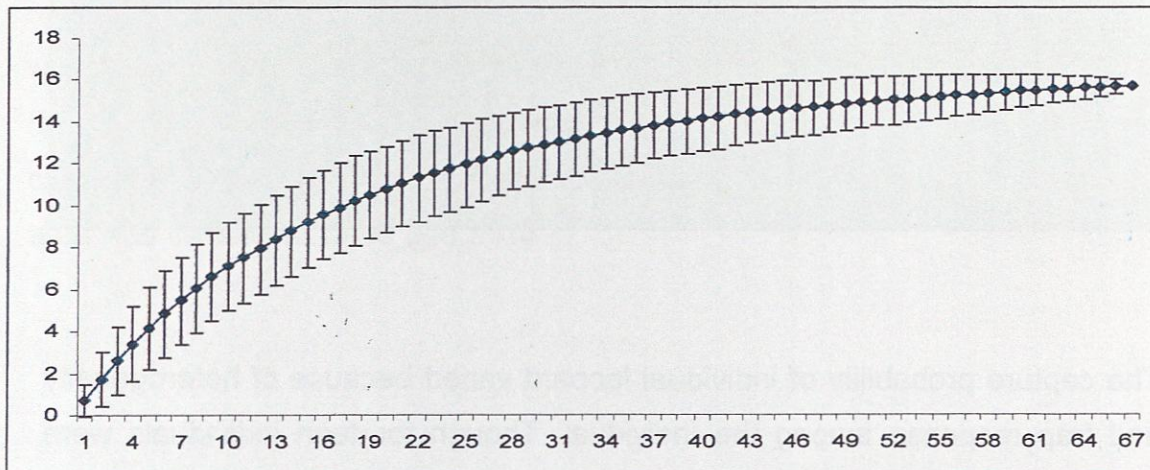
In total we documented 49 photographs of 14 individual leopards over an area of 213.8 km<sup>2</sup> during the study period (Figure 4.2).

Figure 4. 2. Cumulative number of leopard photographed and individual leopards captured with increasing sampling occasions.



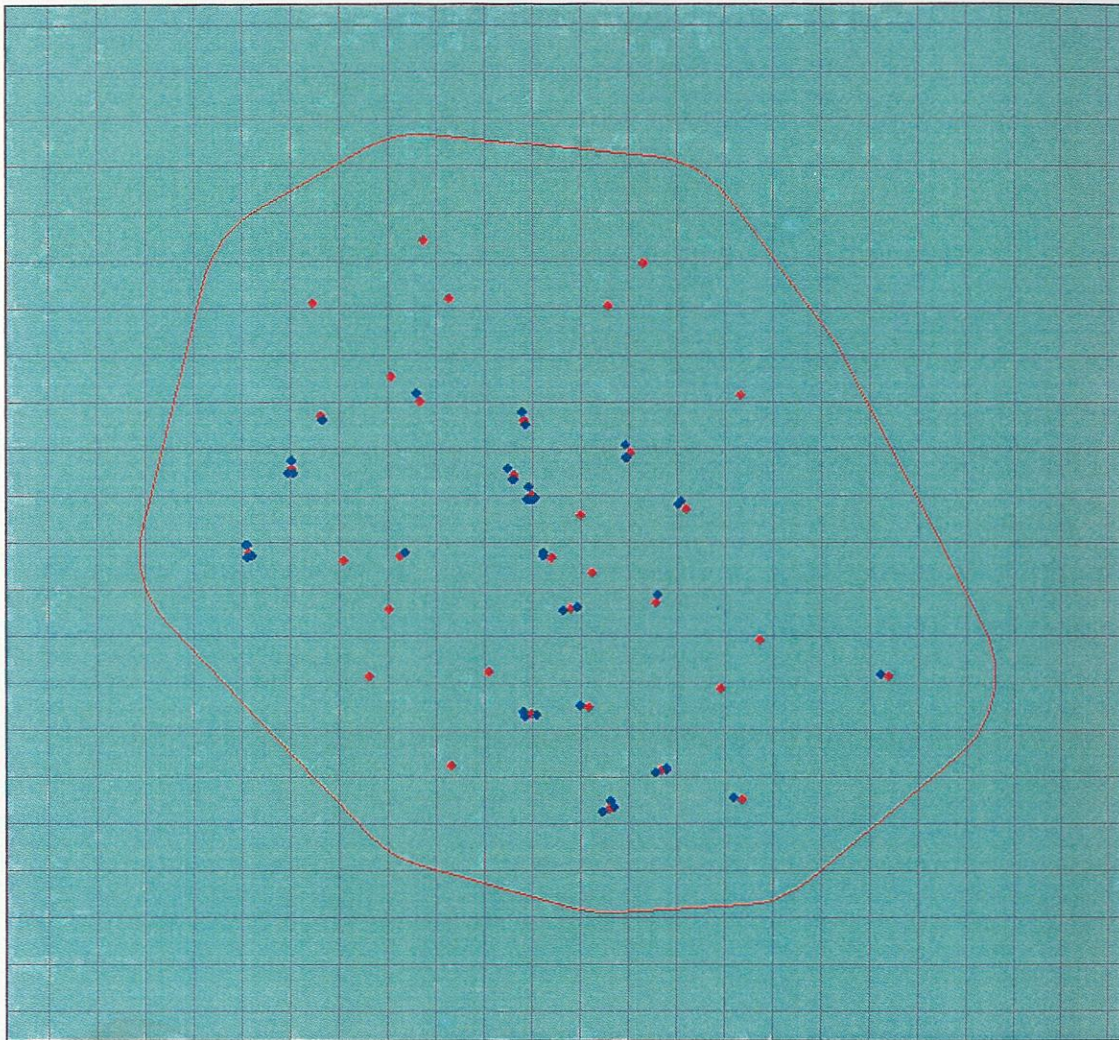
No new animal was photographed after 24<sup>th</sup> occasion, though the number of photographs increased subsequently with the increase of occasion (Figure 4.3). So it is reasonable to believe that most of the leopard, within the sampled area were captured.

Figure 4. 3. Population saturation of leopard with standard deviation as error bar.



We deployed camera traps in 35 sites maintaining 2 km X 2 km grid design in the effective trapping area. Out of 35 locations, in 19 locations, leopards were captured. We estimated the effective trapping area by adding half MMDM buffer strip width with the MCP generated from these 35 locations (**Figure 4.4**).

**Figure 4. 4. Camera trap locations with half MMDM buffer strip width showing the capture points of leopards in Sariska Tiger Reserve.**

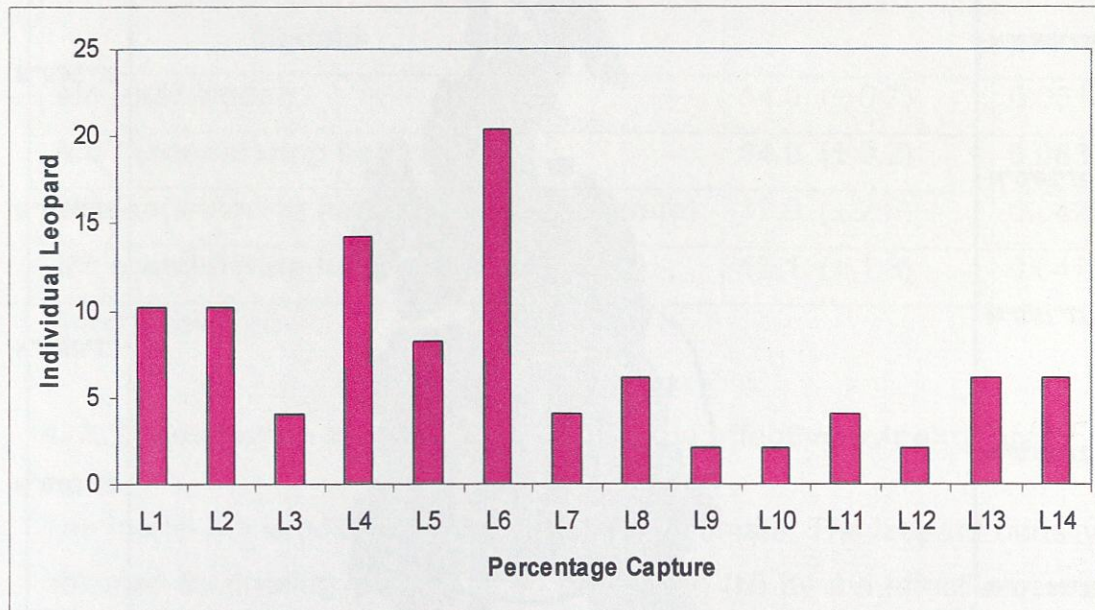


The capture probability of individual leopard varied because of heterogeneity and trap response among the individual. Though fourteen individuals were captured on 67 occasions with all being recaptured at least once, individual recaptures varied from 10 recaptures to one recapture only (**Figure 4.5**). A



total of 3 events of avoidance were noted, contributing to a loss of only 6% of photographic captures.

**Figure 4. 5. Percent capture of individual leopards in Sariska Tiger Reserve.**

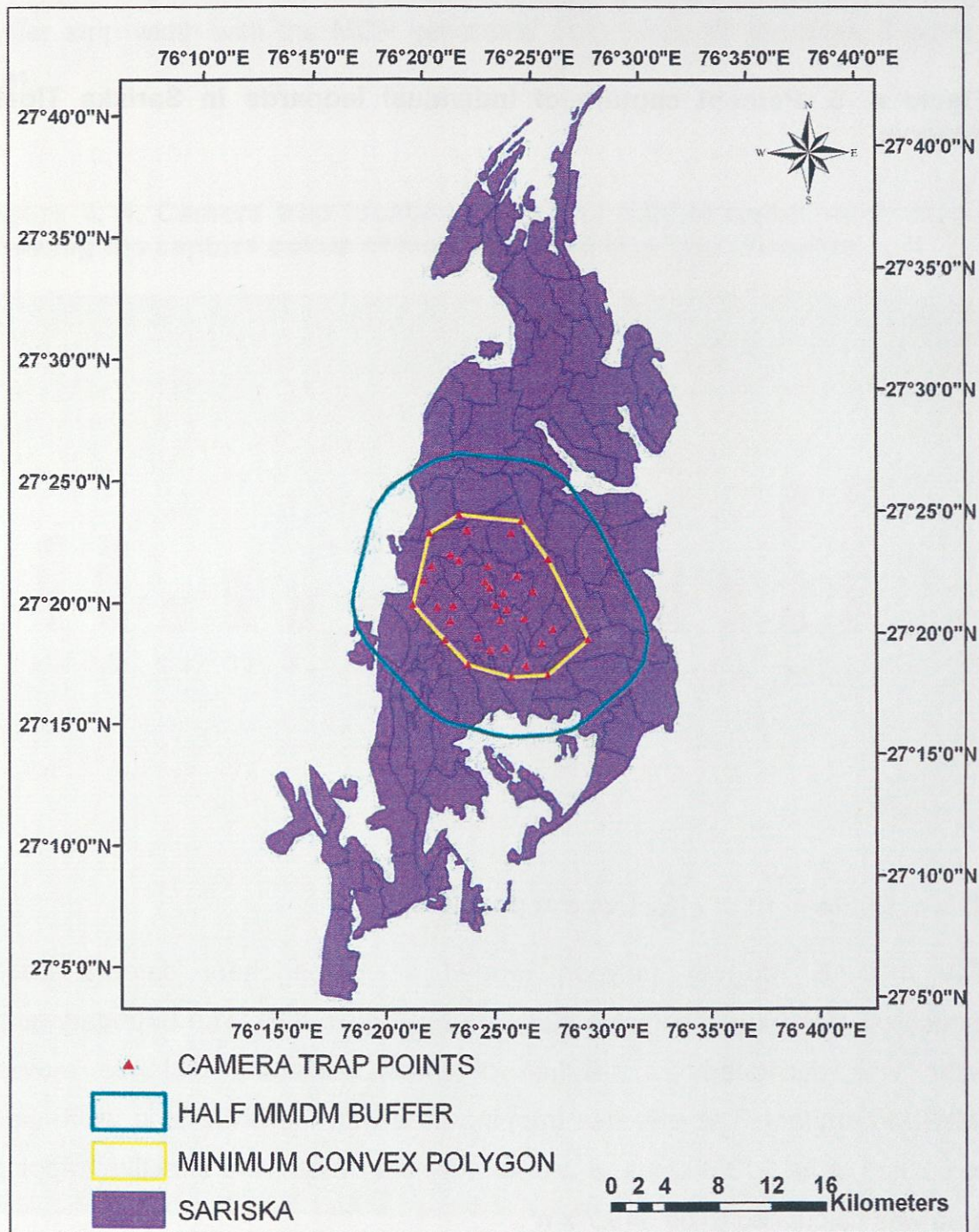


#### 4. 3. 1. Estimation of effective trapping area

The minimum convex polygon formed using periphery camera traps measured 109.6 km<sup>2</sup> (intensive study area) (Figure 4.6). The boundary strip width was estimated by the half of mean maximum distance moved (MMDM/2) model. The effective trapping area with MMDM/2 strip width was calculated to be 213.8 km<sup>2</sup> and with MMDM strip width, the effective trapping area was calculated to be 349.7 km<sup>2</sup>.



Figure 4. 6. Leopard camera trap locations and area covered in Sariska Tiger Reserve.





#### 4. 3. 2. Estimation of leopard population in the study area.

The estimated density of leopards in the study area using different models is given in Table 4.1.

Table 4. 1. Estimated density of leopard using different models.

Models	Population	capture probability
Mo (null model)	14.0 ( $\pm$ 0.7)	0.0516
Mb * (considering behavior)	14.0 ( $\pm$ 0.2)	0.0833
Mh (considering heterogeneity - Jackknife)	17.0 ( $\pm$ 2.6)	0.0426
Mh (considering heterogeneity - Chao)	15.1 ( $\pm$ 1.8)	0.0478

\* model selected

#### 4. 3. 3. Estimation of leopard density in the effective trapping area.

The model Mb is selected as a population estimate. The leopard density was obtained by dividing the estimated population (N) by the effectively sampled area. Thus the estimated leopard density (D) in the study area of Sariska TR is 6.5/100 km<sup>2</sup> or 7 individual per 100 km<sup>2</sup> (Table 4.2).

Table 4. 2. Estimate of leopard density.

Trapping area	Area (km <sup>2</sup> )	Density
Minimum convex polygon	109.6	12.8 ( $\pm$ 0.2)
Half of Mean maximum distance moved	213.8	6.5 ( $\pm$ 0.1)
Mean maximum distance moved	349.7	4.0 ( $\pm$ 0.1)

#### 4. 3. 4. Past studies in Sariska on leopard.

Estimation of population parameter is dependent on efforts in terms of the effective trapping area and sampling sessions. Two studies were available on leopard population estimation using camera traps from a smaller study area (68 to 91 km<sup>2</sup>) in Sariska Tiger Reserve (Chauhan *et al.* 2005 and Edgaonkar *et al.* 2007). Both the studies reported a high leopard population in the trapped area (13 to 16 individuals/ km<sup>2</sup>). Whereas the present study which



was conducted in a large area and over a longer period estimated the leopard population to be 7 individuals / km<sup>2</sup>. Comparisons among the three studies hold that density estimation tends to be high and less precise with less effective sampled area. Thus for any extrapolation of population we need adequate area coverage for sampling as done during the present study. Both the previous studies (Chauhan *et al.* 2005 and Edgaonkar *et al.* 2007) had less effective trapping area and smaller sampling sessions, thus obtained high densities with high standard error (Table 4.3).

**Table 4. 3. Estimated leopard density in Sariska Tiger Reserve (2005 to 2007).**

Study	Year of study	Effective trapping area	No. of individuals captured	Density	SE
Chauhan <i>et al.</i> (2005)	2005	68 km <sup>2</sup> .	9	16	6.85
Edgaonkar <i>et al.</i> (2007)	2005	91.4 km <sup>2</sup> .	9	13.1	--
<b>Present study</b>	2007	213.8 km <sup>2</sup> .	14	7	0.20

#### **4.3.5. Comparison of leopard density in the study area with other studies.**

The estimated leopard density from different forest areas is given in Table 4. 4. It is evident that Sariska Tiger Reserve holds high leopard density which is comparable with other areas as shown in **table 4. 4**. This is attributed to the high abundance of prey base as reported in the present study. It is evident that in all the previous habitats in which tigers were found (Avinandan 2003) in Sariska, are currently occupied by leopard.



**Table 4. 4. Reported leopard densities in different forest areas.**

Study Site	Density/100 sq. km.	Author
Present study	7	Sankar <i>et al.</i> 2007
Satpura National Park	7-10	Edgaonkar 2007
Dholkhand and Beribara	9.8	Mondal 2006
Mera Poh	6	Kawanishi and Sunquist 2004
Kuala Terengan	7	Kawanishi and Sunquist 2004
Kuala Koh	7	Kawanishi and Sunquist 2004
Ngorongoro Np Tanzania	7.5	Kruuk 1972
Hwange, Zimbabwe	2.1	Wilson 1975
Lake Manyara, Tanzania	11	Schaller 1972
Serengeti NP, Tanzania	5.6	Schaller 1972
Nairobi NP, Kenya	8.5	Rudnai 1974
Kruger NP, South Africa	5.1	Pienaar 1969

**4.3.6. Comparison of wild ungulate encounter rate with carnivore species in different beats.**

Encounter rates of wild ungulates in the beats where camera trapping was done and capture rate (per 100 trap nights) of carnivore species in different beats in Sariska Tiger Reserve in Sariska Tiger Reserve are given in **table 4.7 and 4.8** respectively.



Figure 4. 7. Encounter rates of wild ungulates in the beats where camera trapping was done in Sariska Tiger Reserve.

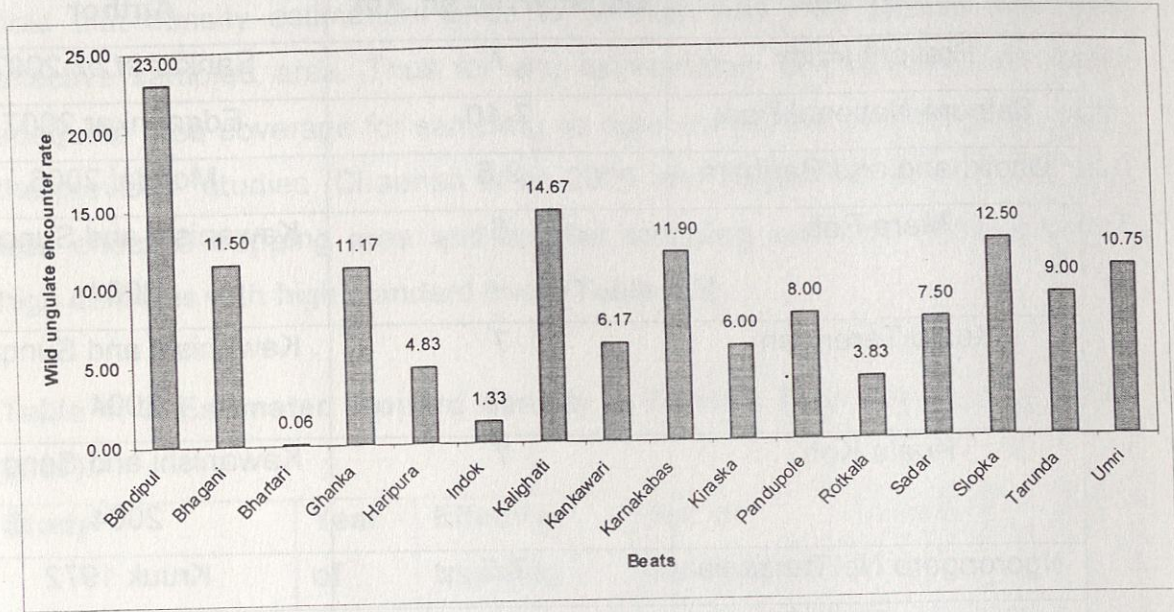
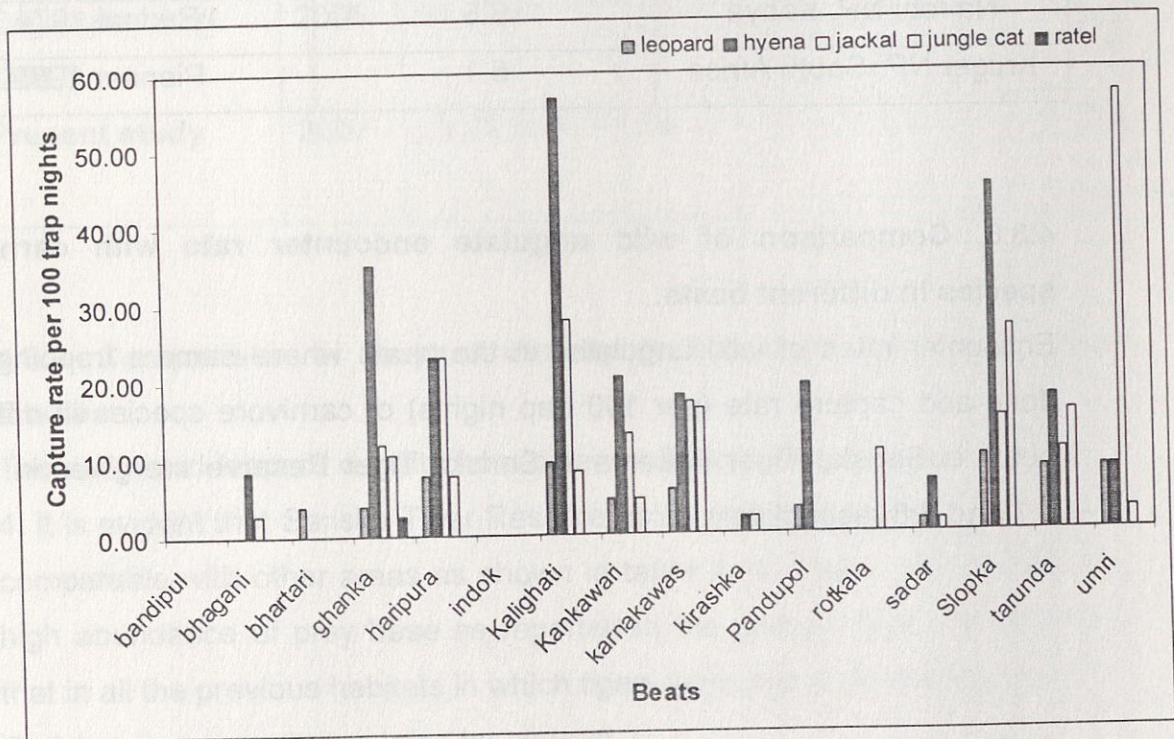


Figure 4.8. Capture rate (per 100 trap nights) of carnivore species in different beats in Sariska Tiger Reserve.

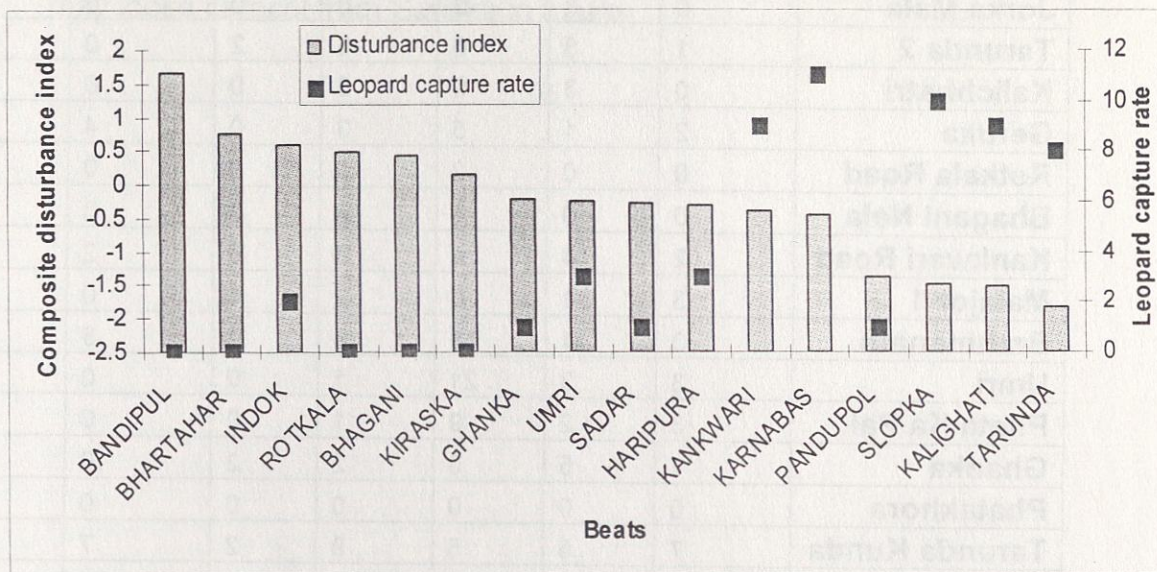


It is evident that the carnivore capture rate in few beats like Bandipul, Bhagani, Bhartari, Indok and Rotkala was very low. These beats were highly disturbed in terms of anthropogenic pressure within the effective trapping area. In Bandipul and Indok and Bhartari there was no evidence of leopard



found and this could be attributed to the presence of Bhartari and Bandipul temples. Lots of pilgrims visit these temples everyday which results in continuous disturbance to the surrounding habitat in these beats. Beats like Kalighati, Slopka, Tarunda, Karnakawas and Umri were observed with less anthropogenic pressure and hence reported higher carnivore signs (Figure 4.9).

**Figure 4. 9. Comparison of leopard capture rate with human disturbance in effective trapping area of STR.**



The data for anthropogenic disturbances (wood cutting, lopping, grazing, grass cutting etc) were collected from line transects of each beat. These disturbance parameters were then analyzed through principal component analysis. Component one was selected as a composite disturbance index which was then compared with leopard capture rates in those beats. It is clear from the figure 5.10 that where composite disturbance is higher indicating low captures of leopard and beats with less disturbances having higher leopard capture rates.

Apart from leopards, the other carnivore species and the number of captures obtained in each camera trap locations is given in **table 4.5**. In total seven carnivore species were recorded. The ratel (*Millivore capensis*) evidence was obtained only from Kalakund area in Sariska.



Table 4. 5. Number of captures of different carnivore species in each camera trap locations.

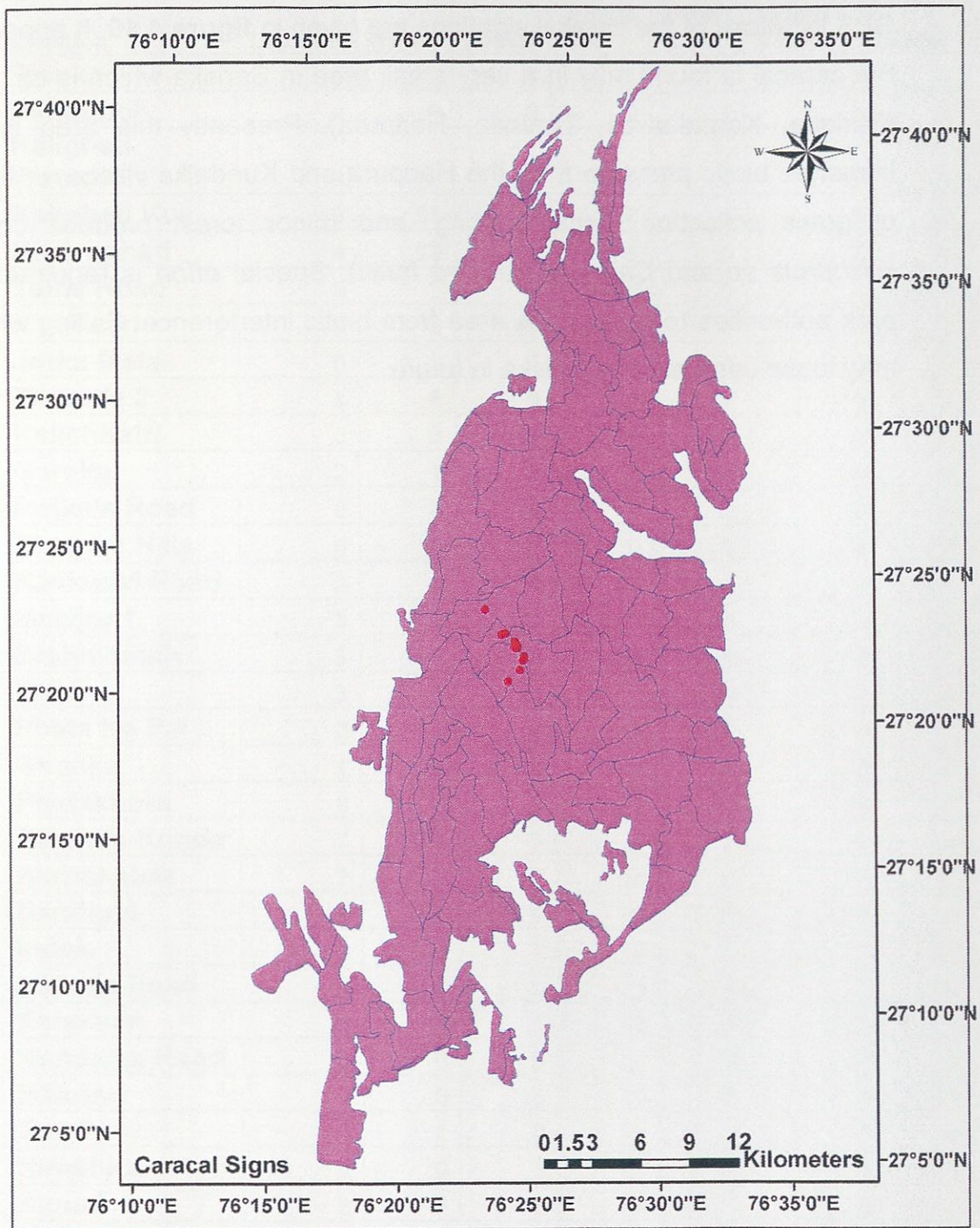
Location	Leopard	Hyena	Jackal	Jungle Cat	Palm Civet	Common Indian Civet	Ratel	Effort
Slopka	3	21	5	15	8	7	0	37
Pandupol	1	6	0	0	1	0	0	31
Kalighati Waterhole	3	13	6	0	1	3	0	31
Kalighati Kua	3	31	3	0	6	5	0	29
Bhairughati	4	23	1	9	0	2	0	30
Tehla Road	0	3	0	0	0	0	0	22
Kankwari	0	15	10	0	1	2	0	19
Jorka Mala	0	2	0	0	0	0	0	15
Tarunda 2	1	8	0	6	2	0	0	37
Kalichhatri	0	3	9	2	0	0	0	24
Geruka	2	1	5	3	0	4	0	22
Rotkala Road	0	0	2	0	0	0	0	19
Bhagani Nala	0	0	1	0	0	0	0	14
Kankwari Road	2	4	4	3	0	2	0	37
Malajor 1	3	1	0	2	4	0	0	37
Brahmanath	3	11	18	8	0	5	0	37
Umri	3	3	21	1	0	0	0	37
Pheta Ka Pal	3	2	9	1	0	0	0	35
Ghanka	1	5	3	2	2	0	0	25
Phatakhora	0	0	0	0	0	0	0	22
Tarunda Kunda	7	5	5	9	2	7	0	30
Karnakabas	2	6	1	11	0	0	0	30
Bandipul	0	0	0	0	0	0	0	10
Indok	0	0	0	0	0	0	0	14
Lilunda Road	0	0	0	0	0	0	0	11
Kalakuan	0	3	1	0	1	0	0	20
Kundalka Road	0	0	0	0	0	0	0	15
Bhartari	1	0	0	0	0	0	0	15
Kund	0	1	0	0	1	0	0	25
Kirashka	0	0	1	0	0	0	0	25
Algual	2	9	3	1	0	0	0	30
Haripura Road	2	6	6	2	0	0	0	26
Kalichautri	0	4	5	0	0	0	0	30
Kalakund	2	22	6	6	0	0	2	30
Ghanka Tiraya	1	1	0	0	0	0	0	25



Though no caracal was captured in any of the camera traps, they were sighted by tourists and Forest Department Staff during the study period. The GPS locations of the caracal sightings are given in **figure 4.10**. It appears that the caracal is found only in a very small area in Sariska which is ca. 25 km<sup>2</sup> (Sariaka, Karnakawas, Tarunda, Haripura). Presently this area is under immense biotic pressure from the Haripura and Kundalka village, in the form of grass collection, cattle grazing, and minor forest produce collection (*Zizhphus sp* and *Capparis decidua* fruits). Special effort is required by the park authorities to protect this area from biotic interference. Failing which we may lose caracal from Sariska in future.



Figure 4. 10. Locations of caracal (based on secondary data) in Sariska Tiger Reserve.

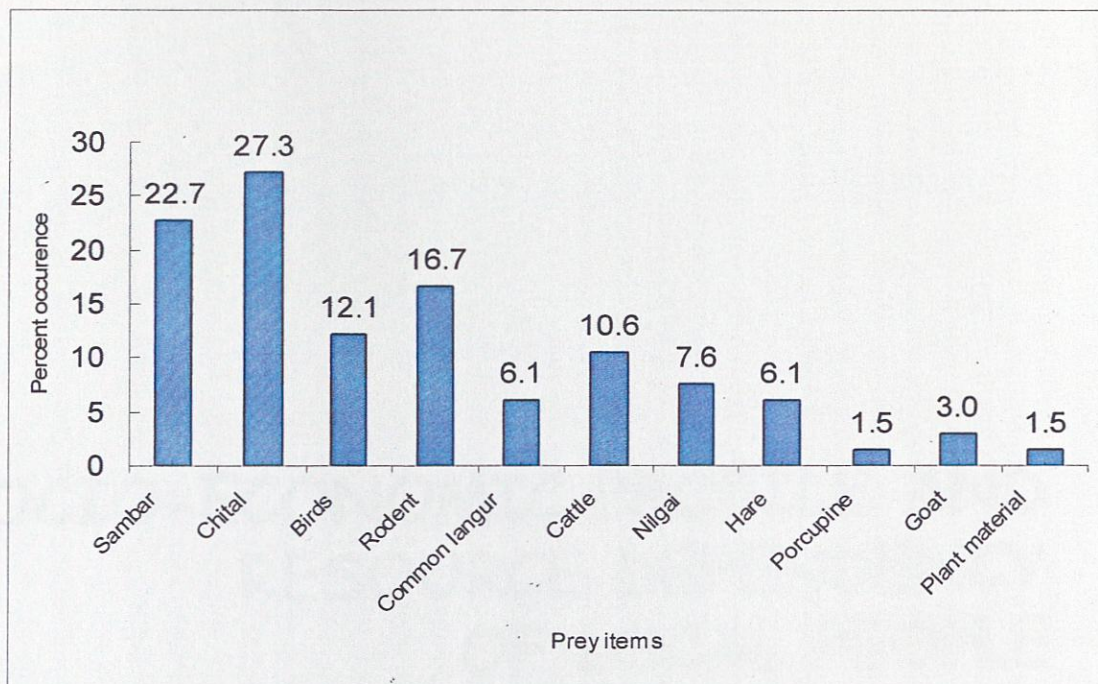




#### 4.3.7. Food habits of leopard.

Food habits of leopard were determined by analyzing scats. In total 66 scats were collected during 2007 wherever encountered. The scats were washed over a sieve, and oven dried at 60°C. A minimum of 20 hairs was taken from each scat (Mukherjee. *et al.* 1994) and they were examined under microscope. Identification of prey species was based on cuticular and medullary pattern of hairs as described by Moorie *et al.* (1974). The frequency of occurrence of a prey item was calculated as the number of times a specific prey items was found to occur in leopard scats (Mukherjee 2004). The majority of (84.8%) scats had single prey species while 15.2% had double prey species. Chital (27.3%) and sambar (22.7%) constituted the major portion in the diet of leopard followed by rodents (16.1%), birds (12.1%), cattle (10.6%), nilgai (7.6%) Rufous tailed hare ((6.1%), common langur (6.1%), goats (3%), porcupine (1.5%) and plant material (1.5%) (Figure 4. 11).

Figure 4. 11. Percent occurrence of prey items in the diet of leopard (n=66) in Sariska Tiger Reserve.



The results obtained were compared with the previous study conducted in the same study area when tigers were present (Sankar and Johnsingh 2002). The



previous study showed that rodent remains were present in leopard scats in very high proportion (45.6%). The higher percentage of rodents remains as found in leopard scats was attributed to high rodent availability in the study area, while chital and sambar remains were found in (20.8%) and (20%) respectively in the leopard scats (Sankar and Johnsingh 2002).

The present study showed that chital and sambar has now become an important prey base for leopard in Sariska Tiger Reserve. The chital and sambar were indeed an important prey base for tigers in Sariska before they were exterminated (Sankar *et al.* 2005). The previous study did not record any livestock remains in the leopard diet.



**SOCIO-ECONOMIC PROFILE AND  
RESOURCE DEPENDENCY  
OF LOCAL PEOPLE**



## 5. SOCIO - ECONOMIC PROFILE AND RESOURCE DEPENDENCY OF LOCAL PEOPLE

### 5. 1 INTRODUCTION

In India, 5 million people live inside nature reserves, and 147 million depend on resources that these reserves provide (Kutty and Kothari 2001). Plant species, especially trees have played an essential role in the livelihood of mankind throughout their history (Olson 1998). Rural population in the Indian subcontinent depends heavily on forest resources (Singhal *et al.* 2003) and resource collection continues in most protected areas despite prohibition (Kothari *et al.* 1989). The relationship between forest resources and the community are determinant upon the socio-economic and socio-cultural characteristics of the community in focus. Conservationists in the recent years view local people's support for protected area management as an important element of biodiversity conservation (Nagothu 2003). This is often linked to the direct benefits, which local communities get from the protected areas in the form of biomass resources, park funds diverted to local villages by state agencies, revenue from wildlife tourism, etc. Western and Wright (1994) considered that the basics for conservation development are the opinions of local communities about nature conservation. In the recent years it is being increasingly recognised that PAs should play a role in sustaining local people's livelihoods (Ghimire and Pimbert 1997) and the context of the discussions within Convention on Biological Diversity (CBD) and its goals of conservation and sustainable use of Biological Diversity, for example Article 10 and 11 of the CBD (Porter *et al.* 1998). Village displacement has been one of the priorities in management of protected areas in India, particularly in Tiger Reserves. In India, village resettlements to promote conservation date back to the 1960's (Ranganjan and Shahabuddin 2006). The Indian Government aims at reducing human pressure on reserves by relocation programmes (Shahabuddin and Shah 2003, Sharma 2003, Ranganjan and Shahabuddin 2006 and Karanth and Karanth 2007). Also, village displacement is known to create "inviolable spaces" which are considered necessary by biologists for sustaining natural ecological functions (Soule and Terborgh 1999).



Sariska Tiger Reserve, located in the Aravalli Hills of Rajasthan, represents a typical example of the complexities and inequities involved in planning large-scale relocation and rehabilitation from within a protected area. Mainly belonging to the Gujjar community, these villagers primarily depend on rearing livestock and selling milk for their livelihood. Biologists have felt for a long time that overgrazing and biomass collection by these communities poses a significant threat to Sariska's natural habitats and biodiversity (Rodgers 1990; John Singh *et.al* 1997). Shahabuddin *et al.* (2005) showed that intensively exploited habitats are subject to changes in vegetation structure and bird community composition. Due to the perceived impact of the local communities on the forest ecosystem, relocation planning has been part of the agenda of the STR for at least two decades (Johari 2003). While two villages from the earlier twelve, Karnakawas, 30 years ago and Bhagani in November, 2007 were relocated till date. The remaining ten villages still occupy a larger part in the Core zone-I of the Tiger Reserve.

Since the early 1970's, development has been denied to these villages because legislation governing PAs prohibits developmental activities such as the construction of roads, clinics or schools (Shahabuddin *et al.* 2005). Over the years, agricultural activities were also curtailed in the villages and grazing and fuelwood use has also been restricted. Consequently, the villagers have been living in a state of deprivation and impoverishment with little access to basic amenities of life and in severe conflict with the Reserve management over rights to forest and livelihoods for the last several decades.

While the local communities have existed under threat of relocation for several years, with the fear of relocation forming an important part of the local discourse (Johari 2003), the actual plan for relocation for 4 of 11 villages from Sariska's Core Zone-I was budgeted and finalized on behalf of the Reserve management in November 2002, and subsequently in July 2005 the relocation plan was approved by the Central Government's Ministry of Environment and Forests (MoEF).



Field work for the present study was undertaken from February 2008 to June 2008 to understand the complexities of the relocation process in Sariska Tiger Reserve and project the perspectives, aspirations and attitude of people facing imminent displacement, to examine the socio-economic, political and ecological contexts of relocation and perhaps most critically, to generate baseline data on socio-economic status, livelihoods and economy of the villages in and around Sariska Tiger Reserve.

Presently, there are 10 villages located inside the Core zone-I of the Tiger Reserve, which are still due for relocation since 1984. One village named Bhagani has already been successfully relocated in November 2008. People living in these villages mostly belong to the Gujjar community, traditionally dependent on livestock for milk-production economy alongwith the Meenas inhabiting some villages. There are very few studies which have attempted to study the direct relationship of the local communities with their environment and their attitude towards conservation and sustainable use of resources. The present study examined the local people's dependencies and their varied opinions towards the Sariska Tiger Reserve (STR). Our field study focused on ten villages in Core zone-I, twenty-two villages outside Core zone-I but within the Tiger Reserve and five villages outside the Tiger Reserve. Therefore, a total of 37 villages were sampled.

## **5. 2 METHODOLOGY**

Data pertaining to the current study was collected using a structured questionnaire and a survey was conducted thus achieving a sampling effort of 45% to almost 100% varying in different villages. A detailed data collection was done from March to May 2008. In all, 37 villages were sampled which were finally classified into three different categories as: Category-I for the villages located inside the Core zone-I (10 villages) of the Tiger Reserve as, Category-II for the villages within the Tiger Reserve but outside Core zone-I (22 villages) and Category-III, for the villages located outside the Tiger Reserve (5 villages). This close-ended questionnaire survey was administered to 275 (52.8%) households of category-I, 751 (47.7%) households of category



11 and 163 (55.8%) households of Category-III (**Table: 5.1**) with varying sampling proportions in different villages. Through the design of the questionnaire an attempt was made to assess the information related to the dependency of the households on forest products, the kind of forest products they harvest as fuelwood, fodder, non-timber forest products, the extent of their dependency on these forest resources, etc.. Information was also gathered from key informants who included informal leaders and local officials during focus group discussions. Households to be questioned were selected randomly from the village. The socio-economic and demographic variables measured were members in the family, level of education, primary occupation, livestock holding, level of income, gender, age, land ownership, quality & quantity of forest product and non-timber forest product collection for each household sampled and lastly some especially designed questions in order to get an overview of the local people's attitude in STR and their views towards conservation.

## **5. 3 RESULTS**

### **5. 3.1 People and livestock**

Out of ten villages in Core zone-I of the Tiger Reserve, Lilunda was found to be the smallest with 20 households whereas Kirashka was the largest with 111 households (**Table 5.1**). Kankwadi, Rekhamala, Dabli and Deori are among the oldest villages in the Reserve of which Kankwadi is said to be at least a thousand years old, inhabited by Bagrawats, Meenas and Rajputs in the past and currently with Gujjars and Meenas to the most with a few Brahmins. Deori too, has very old temples having dates as old as 1820 AD (Kumar and Shahbuddin 2005). Other villages, however, refer their origin to the period of Maharaja Jaisingh of Alwar. Thus, it can be concluded that the Core zone-I villages with their present occupants are at least 100 years old (Kumar and Shahbuddin 2005). Among the villages outside Core zone-I, Madhogarh and Nangledi were found to be the largest with a total of 240 to 250 households in each and Dhulawa was the smallest with only 8 households whereas for villages outside the Tiger Reserve, Thilwad was the



largest with 125 households and Amrakabas was the smallest with 22 households.

The average sex ratio amongst all the sampled households was found to be 82 females per 100 males (**Table 5.2**), which is quite lower than the national average i.e. 93 females per 100 males. The observed sex ratio among Core zone I villages was 77 females to 100 males with the lowest exhibited by Dabli (66 females per 100 males) and the highest (98 females per 100 males) found in Haripura (**Figure 5.1**). Sex ratio for the villages outside Core zone I was found to be the highest in Dhulawa (116 females / 100 males) and lowest in Dabkan (68 females / 100 males). For villages outside the Tiger Reserve, Thilwad had the lowest (72 females / 100 males) and Manabas had the highest (102 females / 100 males) sex ratio. Nearly 38 % of the population sampled falls under the age group of below 14 years, thus indicating a high population growth rate (**Table 5.2**). Also, a high children to female ratio of 1.9: 1 with 189 children per 100 females represents a highly growth in population. The highest children to female ratio was observed in Rotkala (300 children per 100 females) and the lowest in Rekhamala (141 children per 100 females) amongst the sampled households (**Figure 5.3**). For the villages outside Core zone I, children to female ratio was highest in Chhota Kundalka (392 children / 100 females) and lowest in Kushalgarh (107 children / 100 females) whereas the same for villages outside the Tiger Reserve was found to be highest in Amrakabas (280 children / 100 females) and lowest in Lawkabas (145 children / 100 females).

The overall reported literacy rate of the 10 villages within the Core zone-I was about 24.6 %. The lowest literacy rate was reported from Rotkala (0 %) and the highest in Deori (41.8 %) (**Figure 5.4**). A previous study (Shahabuddin 2005) reported that village Lilunda had no literacy. The present study reported a literacy rate of 2.0 % for the same. The literacy rate pertaining to the villages other than Core zone-I was found to be the highest in Thilwadi (39.9 %) and lowest in Manyala (3.8 %). However, among the villages outside the Tiger Reserve, Thilwad reported the highest literacy rate of 45.1 % and Chandpahadi, the lowest with 15.1 % of literacy rate.



Table 5.1 Number of households surveyed and percent sampling achieved in villages of Core zone-I of Sariska Tiger Reserve

S. No.	Village	Range	Beat	Total # of house-holds	# of House-holds surveyed	% House-holds sampled
1	Umri	Akbarpur	Umri	50	30	60
2	Haripura	Sariska	Haripura	35	29	83
3	Kankwadi	Sariska	Kankwadi	91	48	53
4	Kirashka	Sariska	Kirashka	111	50	45
5	Sukola	Akbarpur	Sukola	30	24	80
6	Dabli	Akbarpur	Dabli	46	24	53
7	Rekhamala	Talvriksh	Rekhamala	35	21	60
8	Lilunda	Sariska	Bhartari	20	17	85
9	Deori	Tehla	Deori	65	33	51
10	Rotkala	Akbarpur	Rotkala	38	20	53

Table 5.2 Number of households surveyed and percent sampling achieved in other villages of Sariska Tiger Reserve (excluding Core zone-I)

S. No.	Village	Range	Beat	Total # of house-holds	# of House-holds surveyed	% House-holds sampled
1	Chhota Kundalka	Sariska	Karnakawas	11	10	91
2	Kundalka	Sariska	Sadar	35	24	69
3	Indok	Sariska	Indok	230	154	67
4	Duarmala	Sariska	Duarmala	24	11	46
5	Kushalgarh	Sariska	Kushalgarh	50	24	48
6	Kalachhara	Sariska	Kalachhara	36	29	81
7	Nangledi	Talvriksh	Nangledi	250	43	17
8	Bhairawas	Talvriksh	Bhairawas	250	27	11
9	Madhogarh	Akbarpur	Madhogarh	250	68	27
10	Raika	Akbarpur	Raika	26	15	58
11	Panidhal	Akbarpur	Panidhal	11	11	100
12	Loj	Talvriksh	Loj-Kanpura	62	62	100
13	Mathrawat	Tehla	Rajor	48	48	100
14	Manyala	Tehla	Rajor	12	12	100
15	Rajor	Tehla	Rajor	79	48	61
16	Garh	Tehla	Garh	43	31	72
17	Dabkan	Tehla	Dabkan	55	43	78
18	Bhomighati	Tehla	Dabkan	9	9	100
19	Dhulawa	Tehla	Ajabgarh	8	8	100
20	Bandipul	Tehla	Bandipul	15	15	100
21	Thilwadi	Tehla	Thilwadi	35	33	94
22	Bera	Akbarpur	Kalikhhol	40	26	65
23	Thilwad	Tehla	Thilwad	125	41	33
24	Chandpahari	Akbarpur	Chandpahari	55	28	51
25	Amrakabas	Sariska	Ganeshpura	22	14	64
26	Lawkabas	Sariska	Ganeshpura	50	50	100
27	Manabas	Talvriksh	Manabas	40	30	75

Table 5. 3 Demographic details of different villages in Core Zone-I of Sariska Tiger Reserve

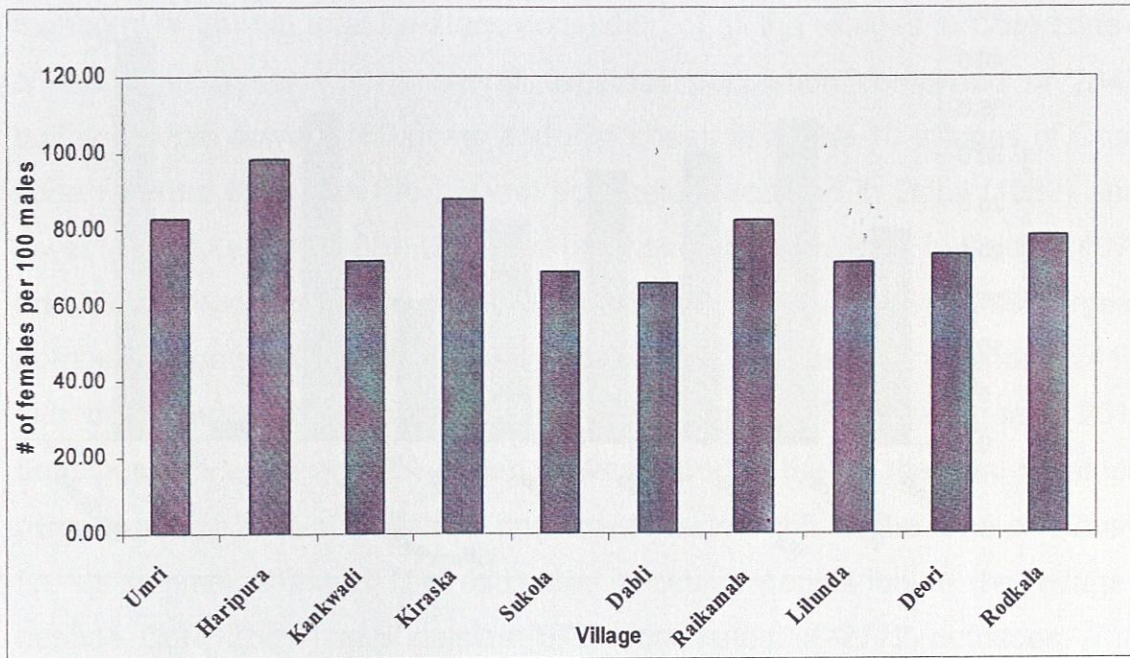
S.No.	Village	Range	Beat	House-holds surveyed	Total Population	Population <14 year	Population >14 year	Population >50 year	Females	Males	Sex ratio (# of females/ 100 males)
1	Umri	Akbarpur	Umri	30	225	70	129	26	102	123	82.93
2	Haripura	Sariska	Haripura	19	121	51	52	18	60	61	98.36
3	Kankwadi	Sariska	Kankwadi	48	273	90	156	27	114	159	71.70
4	Kirashka	Sariska	Kirashka	50	237	90	119	28	111	126	88.10
5	Sukola	Akbarpur	Sukola	24	169	65	88	16	69	100	69.00
6	Dabli	Akbarpur	Dabli	24	214	83	103	28	85	129	65.89
7	Rekhamala	Talvriksh	Rekhamala	21	73	24	38	11	33	40	82.50
8	Lilunda	Sariska	Bhartari	17	101	46	43	12	42	59	71.19
9	Deori	Tehla	Deori	33	182	82	77	23	77	105	73.33
10	Rotkala	Akbarpur	Rotkala	20	91	42	33	16	40	51	78.43

Table 5. 4 Demographic details of other villages of Sariska Tiger Reserve (excluding Core zone-I)

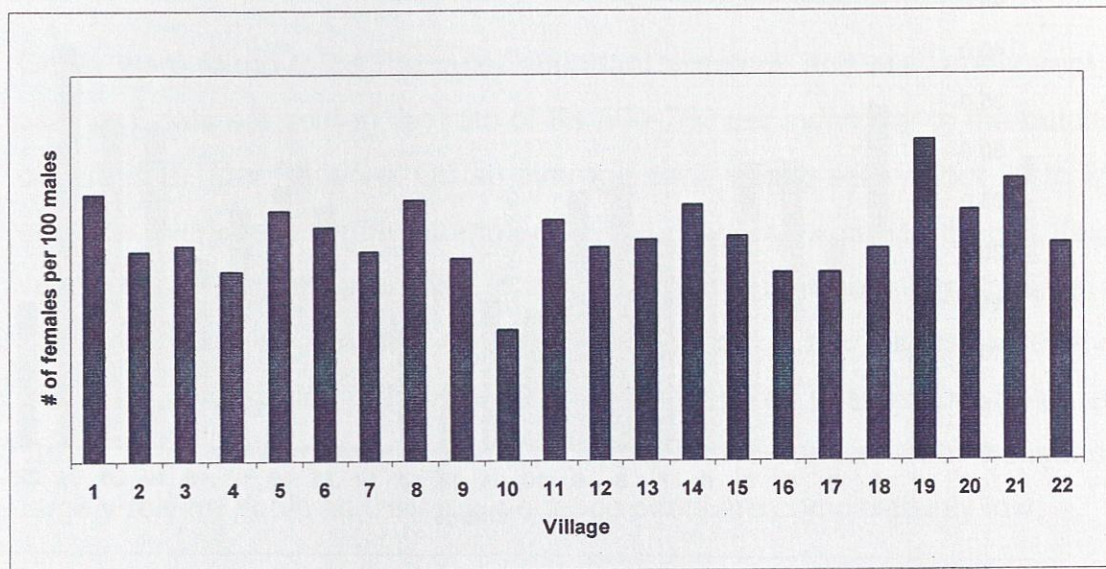
S. No.	Village	Range	Beat	House-holds surveyed	Total Population	Population <14 year	Population >14 year	Population >50 year	Females	Males	Sex ratio (no. females/ 100 males)
1	Chhota Kundalka	Sariska	Karnakawas	10	69	47	22	0	34	35	97.14
2	Kundalka	Sariska	Sadar	24	104	44	49	11	45	59	76.27
3	Indok	Sariska	Indok	154	783	370	368	45	344	439	78.36
4	Duarmala	Sariska	Duarmala	11	93	40	45	8	38	55	69.09
5	Kushalgarh	Sariska	Kushalgarh	24	164	47	97	20	78	86	90.70
6	Kalachhara	Sariska	Kalachhara	29	133	51	77	5	61	72	84.72
7	Nangledi	Talvriksh	Nangledi	43	217	77	117	23	94	123	76.42
8	Bhairawas	Talvriksh	Bhairawas	27	195	93	90	12	95	100	95.00
9	Madhogarh	Akbarpur	Madhogarh	68	465	186	265	14	197	268	73.51
10	Raika	Akbarpur	Raika	15	130	56	63	11	42	88	47.73
11	Panidhal	Akbarpur	Panidhal	11	60	28	26	6	28	32	87.50
12	Loj	Talvriksh	Loj-Kanpura	62	290	121	152	17	127	163	77.91
13	Mathrawat	Tehla	Rajor	48	333	106	176	51	148	185	80.00
14	Manyala	Tehla	Rajor	12	79	37	38	4	38	41	92.68
15	Rajor	Tehla	Rajor	48	298	109	171	18	134	164	81.71
16	Garh	Tehla	Garh	31	219	72	113	34	89	130	68.46
17	Dabkan	Tehla	Dabkan	43	202	62	131	9	82	120	68.33
18	Bhomighati	Tehla	Dabkan	9	53	18	33	2	23	30	76.67
19	Dhulawa	Tehla	Ajabgarh	8	41	23	16	2	22	19	115.79
20	Bandipul	Tehla	Bandipul	15	63	22	38	3	30	33	90.91
21	Thilwadi	Tehla	Thilwadi	33	188	72	96	20	95	93	102.15
22	Bera	Akbarpur	Kalikhoh	26	252	111	126	15	111	141	78.72
23	Thilwad	Tehla	Thilwad	41	237	94	100	43	99	138	71.74
24	Chandpahari	Akbarpur	Chandpahari	28	159	75	74	10	72	87	82.76
25	Amrakabas	Sariska	Ganeshpura	14	99	56	39	4	48	51	94.12
26	Lawkabas	Sariska	Ganeshpura	50	321	112	186	23	137	184	74.46
27	Manabas	Talvriksh	Manabas	30	250	110	122	18	126	124	101.61



**Figure 5. 1 Human sex ratios in different villages in Core zone-I in Sariska Tiger Reserve**



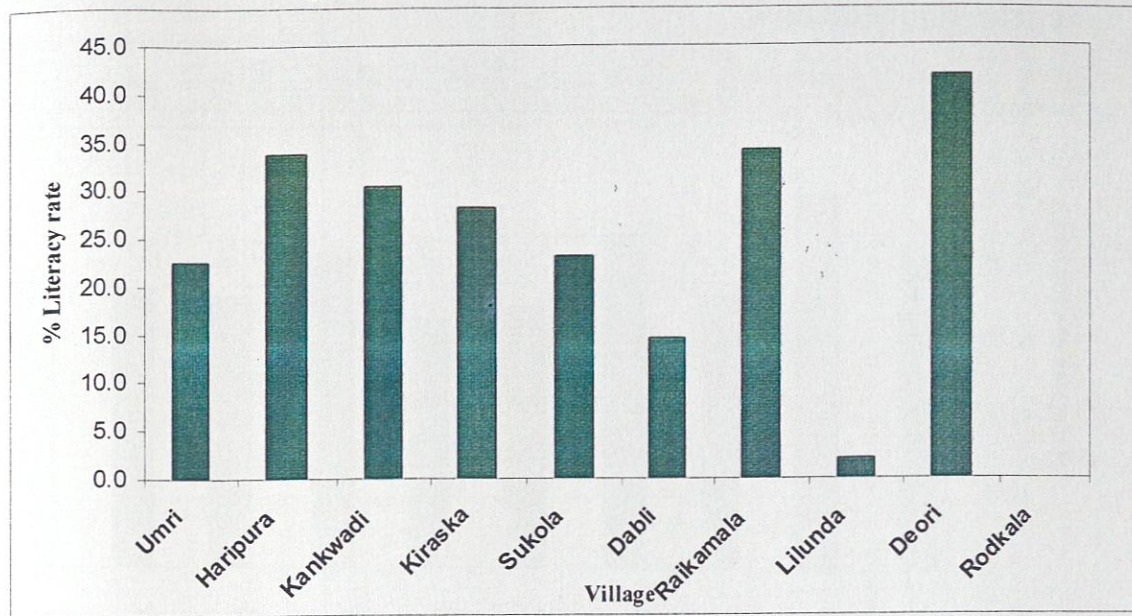
**Figure 5. 2 Human sex ratios in other villages surveyed in Sariska Tiger Reserve (excluding Core Zone-I)**



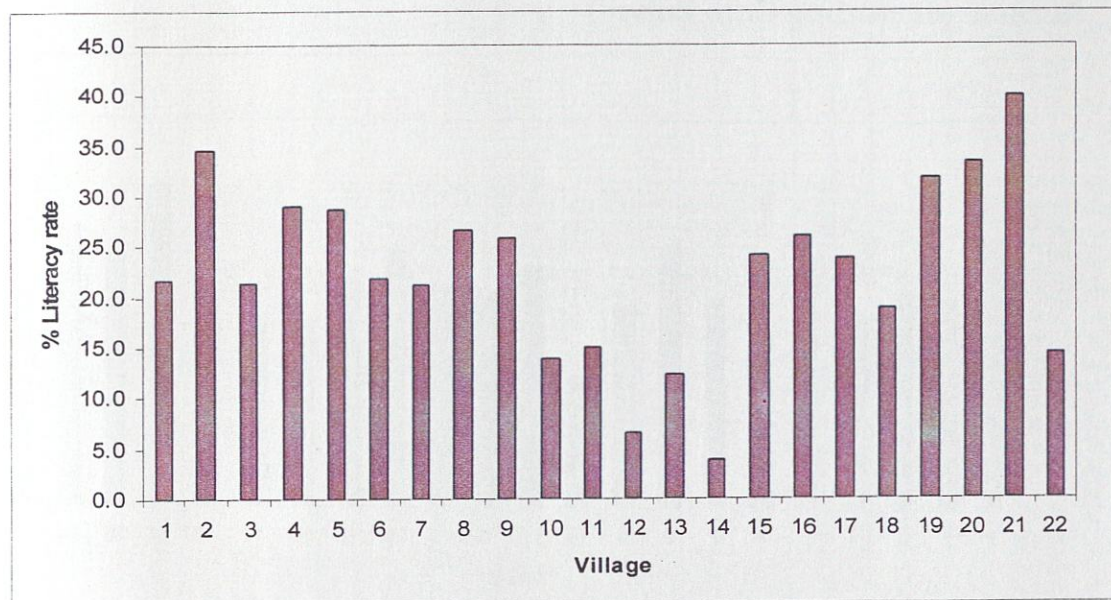
1; Chhota Kundalka, 2; Kundalka, 3; Indok, 4; Duarmala, 5; Kushalgarh, 6; Kalachhara, 7; Nangledi, 8; Bhairawas, 9; Madhogarh, 10; Raika, 11; Panidhal, 12; Loj, 13; Mathurawat, 14; Manyala, 15; Rajor, 16; Garh, 17; Dabkan, 18; Bhomighati, 19; Dhulawa, 20; Bandipul, 21; Thilwadi, 22; Bera



**Figure 5.3 Literacy rate among the villagers in different villages in Core Zone I of Sariska Tiger Reserve.**



**Figure 5.4 Literacy rate among the villagers in other villages of Sariska Tiger Reserve (excluding Core Zone-I).**



1; Chhota Kundalka, 2; Kundalka, 3; Indok, 4; Duarmala, 5; Kushalgarh, 6; Kalachhara, 7; Nangledi, 8; Bhairawas, 9; Madhogarh, 10; Raika, 11; Panidhal, 12; Loj, 13; Mathurawat, 14; Manyala, 15; Rajor, 16; Garh, 17; Dabkan, 18; Bhomighati, 19; Dhulawa, 20; Bandipul, 21; Thilwadi, 22; Bera



Irrespective of the sampling effort which was not 100% in all the villages, we managed to get the total livestock population of all the villages in Core zone-I of the Tiger Reserve. The overall livestock population comprised of 2643 buffaloes, 896 cows, 6160 goats and 234 sheep in all the 10 villages of Core zone I (**Table 5. 5**) with the highest population recorded in Dabli (1082) and lowest in Rekhamala (408). Umri had the maximum number of buffaloes (407) and Lilunda had the least number (105) whereas Kankwadi owned the largest number of goats (1082) and Rekhamala had the least number of goats (241). Out of the entire livestock holding of the villagers, 63% were goats, 25% buffaloes, 9% cows and 2% sheep. It was reported that of the total livestock owned, nearly 25% of buffaloes and cows yielded milk at the time of survey i.e. in summer season. The estimated livestock population in the villages outside Core Zone-I and outside STR constituted of 2722 buffaloes, 718 cows, 6720 goats and 223 sheep, camel and donkey (6) were reported in Indok, Duarmala, Bhairawas and Mathurawat. An overall estimate of livestock population was 20,104 for the entire Tiger Reserve.

Goats were found to be the most abundant livestock and are largely kept for selling. Goats are sold at the rate of Rs 500-700 per individual to the butchers outside the Tiger Reserve. On an average each village sells about 20 to 25% of goats every year. During summers some villagers exchange their buffaloes with goats, as goats are easy to maintain being browsers. Goat herds are commonly doubled in a year and thus are the most prized assets for relatively better-off households. Therefore, for the villagers, possessing goats and sheep are an alternative in times of drought and hunger. Poor households largely rely on goats as their maintenance costs are comparatively low.

Buffaloes were the second most abundant livestock in the villages surveyed. Buffaloes are treated by people as members of their family, each having an individual name. The children play the game of guiding the buffaloes to the yard and also sing songs to call their gods *Bhoomia* and *Mahadev*, in order to protect their livestock from large carnivore predation, any disease and to improve the milk yield (Shahabuddin *et al.* 2005). It was reported that buffaloes are sent out of the STR during summer where they feed on the



agricultural waste. The percentage increase in the overall livestock population for the last four years i.e. from 2004 (Shahabuddin 2005) to 2008 is estimated to be 129%. However, it is observed that the increase in the number of cattle and sheep is much higher as compared to the number of buffalo and goat number (Figure 5.6).

Table 5.5 Total livestock population in different villages in Core Zone-I of Sariska Tiger Reserve

S.No	Village	Range	Beat	No. of households	Buffalo	Cow	Goat	Sheep	Donkey	Camel
1	Umri	Akbarpur	Umri	50	407	116	919	100	0	0
2	Haripura	Sariska	Haripura	35	197	42	220	4	0	0
3	Kankwadi	Sariska	Kankwadi	91	377	170	1082	117	1	1
4	Kirashka	Sariska	Kirashka	111	368	181	858	0	0	0
5	Sukola	Akbarpur	Sukola	30	191	37	434	3	0	0
6	Dabli	Akbarpur	Dabli	46	291	184	1071	0	0	0
7	Rekhamala	Talvriksh	Rekhamala	35	149	18	241	0	0	0
8	Lilunda	Sariska	Bhartari	20	105	54	338	10	0	0
9	Deori	Tehla	Deori	65	183	63	506	0	0	0
10	Rotkala	Akbarpur	Rotkala	38	195	31	491	0	0	0



Table 5. 6 Total livestock population in different villages of Sariska Tiger Reserve (excluding Core Zone-I)

S.No	Village	Range	Beat	House-holds surveyed	Buffalo	Cow	Goat	Sheep	Donkey	Camel
1	Chhota Kundalka	Sariska	Karnakawas	10	103	73	218	0	0	0
2	Kundalka	Sariska	Sadar	24	99	51	116	0	0	0
3	Indok	Sariska	Indok	154	338	108	707	0	0	1
4	Duarmala	Sariska	Duarmala	11	92	10	240	0	2	0
5	Kushalgarh	Sariska	Kushalgarh	24	50	12	39	0	0	0
6	Kalachhara	Sariska	Kalachhara	29	156	24	421	0	0	1
7	Nangledi	Talvriksh	Nangledi	43	58	32	188	0	0	0
8	Bhairawas	Talvriksh	Bhairawas	27	27	5	33	0	1	0
9	Madhogarh	Akbarpur	Madhogarh	68	234	34	487	0	0	0
10	Raika	Akbarpur	Raika	15	155	20	313	0	0	0
11	Panidhal	Akbarpur	Panidhal	11	90	5	167	0	0	0
12	Loj	Talvriksh	Loj-Kanpura	62	124	34	276	0	0	0
13	Mathrawat	Tehla	Rajor	48	200	56	778	95	1	0
14	Manyala	Tehla	Rajor	12	36	4	214	80	0	0
15	Rajor	Tehla	Rajor	48	193	85	510	10	0	0
16	Garh	Tehla	Garh	31	118	29	60	0	0	0
17	Dabkan	Tehla	Dabkan	43	36	27	220	8	0	0
18	Bhomighati	Tehla	Dabkan	9	9	8	5	0	0	0
19	Dhulawa	Tehla	Ajabgarh	8	18	1	35	0	0	0
20	Bandipul	Tehla	Bandipul	15	48	5	77	0	0	0
21	Thilwadi	Tehla	Thilwadi	33	44	22	231	0	0	0
22	Bera	Akbarpur	Kaikhoh	26	41	32	151	0	0	0
23	Thilwad	Tehla	Thilwad	41	44	4	81	0	0	0
24	Chandpahari	Akbarpur	Chandpahari	28	208	14	603	0	0	0
25	Amrakabas	Sariska	Ganeshpura	14	88	8	115	0	0	0
26	Lawkabas	Sariska	Ganeshpura	50	100	6	394	30	0	0
27	Manabas	Talvriksh	Manabas	30	13	9	41	0	0	0



Figure 5.5 Percent occurrence of different livestock species in the villages in Core Zone-I of Sariska Tiger Reserve

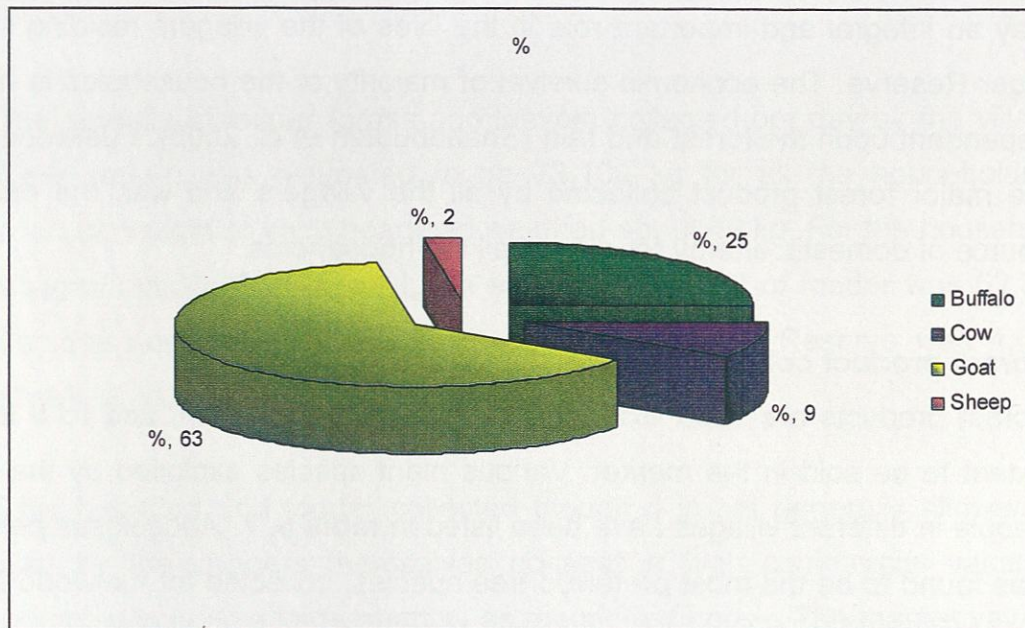
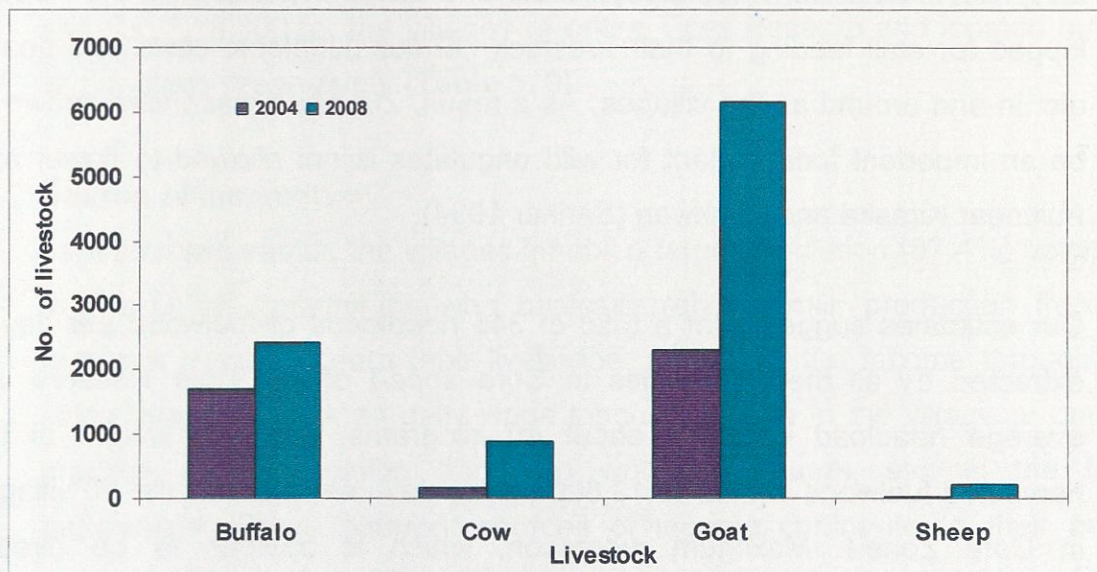


Figure 5.6 Observed difference in the total livestock population from 2004 to 2008 in 10 villages of Core zone-I of Sariska Tiger Reserve.



#### 5. 4. 2. Socio-economic profile:

The study indicates that the indigenous tree species of Sariska Tiger Reserve play an integral and important role in the lives of the villagers residing in the Tiger Reserve. The economic survival of majority of the households is highly dependent upon the forest and rain (Shahabuddin *et al.* 2005). Fuelwood was the major forest product collected by all the villagers and was the primary source of domestic energy for almost all the households.

#### Forest product collection:

Forest products are used extensively for own consumption, and to a lesser extent to be sold in the market. Various plant species exploited by the local people in different villages have been listed in **table 5. 7**. *Anogeissus pendula* was found to be the most preferred tree species, collected for fuelwood by all the villagers inside and outside the Tiger Reserve. Among the grass species, *Apluda mutica* and *Heteropogon contortus* were largely collected by the villagers for stall feeding to buffaloes and cows. Incidentally these grass species grow only on hill slopes and for collecting the same people have to travel long distances from their respective villages. *Anogeissus pendula*, *Zizyphus mauritiana*, *Phoenix sylvestris* and *Butea monosperma* are heavily lopped for stall feeding to their livestock i.e. the buffaloes, cows and goats, etc. in and around all the villages. As a result, *Zizyphus mauritiana* known to be an important fodder plant for wild ungulates is not allowed to flower and fruit near Kiraska and Kankwari (Sankar 1994).

Our estimates suggest that a total of 345 headloads of fuelwood per day is extracted by all the 10 villages in Core zone-I of the Tiger Reserve. An average headload weighing about 40 kilograms, the total weight of the harvested fuelwood comes to 13,800 kg per day combined for the 10 villages in Core Zone-I. Maximum extraction, which is obvious to be directly proportional to the number of households was reported from Kirashka, minimum being from Lilunda. Similarly, for the villages outside Core Zone-I, daily fuelwood exploitation is estimated to be 30,300 kg per day and 5,400 kg per day for the villages located outside the Tiger Reserve. A list of exploited



trees, shrubs and grass species in the entire Tiger Reserve is given in **table 5.7**.

The quantity of fodder (grass and leaves) collected per day by the villages in Core zone-I, was estimated to be 73,100 kg for all the households. The average weight of each headload weighed about 45 kg. For the households in villages outside Core Zone-I, the estimated harvest of fodder was 52,800 kg per day and figure for the same outside the Tiger Reserve was 4,600 kg (**Table 5.8**).

This fuelwood and fodder collected though it is not generally allowed to be sold by the villagers themselves possess a high commercial value being collected in such a large quantity as mentioned above. The market value for a single headload of fuelwood is approximately Rs.20 and Rs. 5 for one headload of fodder. This cost when combined with the quantity of fuelwood exploited annually gives an economic value of Rs. 83,31,000 for the entire Tiger Reserve and Rs. 10,20,100 for the villages outside the Reserve. Similarly, for annual fodder exploitation the estimated value is Rs 52,36,300 and Rs. 7,18,100 for the villages of entire Tiger Reserve and located outside its periphery respectively (**Table 5.9**).

#### **Source of income:**

As discussed earlier, the villages inhabit a large population (87.4%) belonging to the Gujjar community, who basically rely on milk production from the livestock owned to earn their livelihood. Alongwith the income through milk sales they also work as daily wage labourers either in the village or outside, practice crop cultivation and also work as guards, etc. in the forest department. These different sources of income contribute to their annual household income in different proportions as given in **table 5.11 and 5.12**. The milk production greatly varies among different seasons i.e. summer and monsoon and is almost doubled or even more than that in the monsoon. For instance, in Rekhamala the average milk produced per day in summer was reported to be 8 litres which reaches upto 36.5 litres in monsoon. Almost similar is the case reported by other villages sampled. Therefore, in monsoon



milk production being the highest, people generally save money for the entire year ahead. Total milk produced among the households sampled was 2,028 litres per day in summer season from which about 1,413.5 litres (70 %) is sold daily from all the villages of Core zone-I. For the other villages in the Tiger Reserve excluding Core-I, the milk produced per day among the sampled households was 1465 litres and milk sold was 1283.5 litres (87.6%) and for the sampled villages located outside the Tiger Reserve, the estimated milk production to be 233 litres and 203 litres sold (87%) per day. The milk is usually sold to a local dealer from within the village itself, who then sells it at the next level. This middleman connects the villagers to the larger markets at Alwar, Bhartari, Tanagazhi and Tehla and earns a great deal out of it for his own self. While the milk from Umri, Kankwadi, and Kundalka is supplied mainly to the dairies at Tehla and Bhartari, from Deori and Rotkala, it goes to Tehla dairy. Milk from Haripura generally reaches the Forest Department complex in Sariska, and to the local shops at Bhartari Tiraha, etc. The milk is sold for Rs.15 to 18 per litre in summer which drops down to 10 to 12 Rs. per litre in the monsoon, the milk production being high. This generates a total income of Rs. 38070 per day for all the 32 villages inside the Tiger Reserve and Rs. 3278.60 for the sampled villages outside the Tiger Reserve during summer and Rs. 84560 and Rs. 4900 per day during monsoon and winter for villages inside and outside the Tiger Reserve respectively. People living in more inaccessible villages like Kiraska, Dabli, Sukola, Rekhamala, Lilunda and Rotkala however, largely sell *ghee* and *mawa* instead of milk, the reason being that there are no roads for the vehicles to connect them with nearby townships. Direct cost of selling their products is paid to those themselves approach the larger markets at Alwar, etc. otherwise they are supposed to compromise with the low price paid by the local dealers. The price of *mawa* varies from Rs. 70 to Rs. 100 across these villages. Also, a major portion of milk produced is sold locally in village to a person who prepares *mawa* and *ghee*. Average *mawa* production is reported to be around 8.5 kg/day, the *mawa* production sometimes reaches 12 kg/day during monsoon.

Though agricultural practices, goat selling, daily labour and working outside contribute to the annual household income, the average household economy



of the villagers is mainly based on animal husbandry and milk sales, which literally subsists on the edge. Milk sales contributed to a major 66% of the annual household income on an overall basis. Among the villages in Core zone-I, only Deori and Dabli were found to earn through cultivation of crops as they owned some land inside STR whereas outside the Core Zone-I, Garh was found to have the highest per family annual income (Rs. 9789.60) and Kushalgarh with the least (Rs. 872.06). None of the villagers from Core zone-I reported to work as daily wage labourers inside or around the Tiger Reserve but they did work outside as drivers, guards, and labourers, etc. with highest per family annual income (PFAI) earned by Umri and Kiraska. For villages outside Core Zone-I and even outside STR, highest PFAI by daily labour was found for Dhulawa (Rs. 7200) and lowest for Mathurawat (Rs. 3150). Also a number of villages were found with no income from daily labour (**Table 5.11 & 5.12**). As mentioned earlier, goats also serve as an immediate source of income at the time of emergency, Dabli and Kirashka reported the highest PFAI (Rs. 3300) through goat selling in Core zone I whereas the same outside Core Zone-I and outside STR was found from Lawkabas and Manabas Rs. 2250 & Rs. 2000 respectively with least in Raika (Rs. 450.00). Apart from the different sources to earn their livelihood, an average expenditure of Rs. 2500 to 3000 was reported per household per month for smaller families, while Rs. 5000 to a maximum for larger families.

The villagers almost entirely depend on the forests for their livelihood. Traditionally a pastoralist community, their main source of income is selling milk, *mawa* and *ghee* but the villagers do work outside as daily wage labourers as a secondary occupation. From the villages inside the Core Zone-I, 24% of the households sampled had individuals working at other places like Delhi, Jaipur, Bhiwadi, Bharatpur, Tehla, Alwar and even within Sariska as daily wage labourers, driver, forest guards, etc. for a time period of 3 to 6 months generally. The percentage being highest (38%) in Kirashka and lowest (8%) in Sukola. Whereas villages outside Core zone I had 18% of households where people worked outside for varying time periods and the highest i.e. 32% being for the villages outside the Tiger Reserve.



### **Land holding:**

The villages like Dabli, Deori and Rekhamala being revenue villages also owned agricultural land both inside and outside the Tiger Reserve. People here mainly grow wheat, corn, oat, mustard and gram largely for their own consumption. Though the land holdings of the villages inside the Core zone-I of the Tiger Reserve were low in comparison to those owned by the villagers outside the Core zone-I and the villages located outside the Tiger Reserve. Out of the total 275 households sampled in Core Zone-I, 73 households (26.5%) owned land within the Tiger Reserve covering a total area of nearly 215 bighas and 11 households (4%) have land outside the Tiger Reserve at places like Thanaghazi, Lalpura, Tehla and Lausal. Village Deori had the maximum land holding (106.5 bighas) while Sukola had the least land owed (3 bighas) (**Table 5.13**).

Among the villages outside Core Zone-I, in all 751 households were surveyed, whereas 562 (74.83%) of them had land inside the Tiger Reserve with a total area of 1928.8 bighas and 12 households in Chhota Kundalka and Duarmala had land outside the Tiger Reserve at places like Thanaghazi and Duar. Out of all the households surveyed at Duarmala all except one owned land at Duar as most of them shifted to Duar in summer season, since no water was available at Duarmala. Out of 163 households sampled outside the Tiger Reserve 153 households (93.87%) owned land outside the Reserve, covering a total area of 570.8 bighas, Lawkabas with maximum land holding and Chandpahadi the minimum.

### **Level of education:**

Almost all the villages surveyed had a primary Government school with Chandpahari and Indok having two of them for the villagers to get education at least upto primary level except one village i.e. Rotkala which had no school. Literacy rate reported among the children was quite appreciable as compared to the adults for the same. An overall literacy rate of 24.6%, as already mentioned earlier was reported for the villages in Core Zone-I of the Tiger Reserve. Among which 48.2 % children are educated and 10.07% adults with a maximum number of children educated in Kankwadi (83.3%) and maximum



number of educated adults (22.9%) in Haripura. The villages outside the Core Zone-I reported a literacy rate of 21.7 %, with 34.5% literate children and comparatively higher (13.0%) percentage of literate adults. The literacy among adults was found to be highest in Thilwadi (26.7%) and for children it was about 63% for Bandipul and Thilwadi. While, for the villages outside the Tiger Reserve, the overall literacy rate of 27% was reported with 40.9 % literate children and 17.4% literate adults.

#### **Livestock grazing distance:**

The livestock from almost every village are taken out daily for grazing in the forest, though the distances travelled vary among different villages. An average distance of 3.3 km has been reported by the villagers in Core zone I of the Tiger Reserve with the longest distance travelled in the village Rekhamala (4.5 km) and the shortest for Deori i.e. 1.5 km (**Figure 5.9**). A more or less similar to the above figure was estimated for the villages outside Core zone I and even outside the Tiger Reserve i.e. 3.1 km with maximum (11 km) in Garh and minimum (1 km) in Dhulawa and Bhairawas (**Figure 5.15**). Thus, the estimated percentage of area left relatively undisturbed for wildlife is less than 15% for Core Zone-I and less than 10% for the entire Tiger Reserve.

#### **Anthropogenic pressures:**

The other anthropogenic disturbances caused by villagers were wood cutting, grass cutting, lopping and collection of Non Timber Forest Product (NTFP). A 100 % lopping and grass cutting was found in Kankwadi, Bhagani, Rekhamala, and Lilunda while in Haripura and Kiraska 79% lopping and grass cutting was reported. The wood cutting was observed highest in Kankwadi (41.5%) and lowest in Haripura (17%). The other factors like NWFP was found higher in Lilunda (85%) and lower in Haripura (37%) (**Figure 5.16**).

The observed overall anthropogenic pressure (from highest to lowest) in the 10 villages is in the order: Lilunda > > Rekhamala > Kankwari > Umri > Sukola > Kundalka > Deori > Dabli > Kirashka > Haripura (based on questionnaire survey). The reported lowest disturbance around Haripura village may be



attributed to the village proximity to Sariska head quarter and main tourism zone (Core Zone-I).

Various human disturbance factors such as wood cutting, lopping and grazing were assessed across the entire Tiger Reserve during the study conducted in 2007. In all line transects at every 250 m we assessed the intensity of wood cutting, lopping, grazing and weed abundance at a scale of 0-4 (0- no, 1- low <25%, 2- medium 26-50%, 3- high 51-75%, 4- very high >76%) in 10 m radius plot. For each beat the average values of each disturbance factor were assessed and plotted in GIS domain and mapped (Figure 5.17, 5.18, 5.19). It is evident that no forest beats in Sariska Tiger Reserve remain undisturbed. It is estimated by the current study that nearly 20,112 livestock graze/browse inside the Tiger Reserve everyday.

#### **Extent of awareness and attitude towards conservation:**

The characteristics of respondents among the three categories of different villages surveyed, categories again formed in relation to their location in the Tiger Reserve is provided in **Table 5.14**. The inhabitants of Core zone-I villages had surprisingly less knowledge about the fact that tigers have disappeared from the area, even after living in the core zone-I of the Reserve as only 78.9% of the respondents had a clear idea about tiger disappearance and the rest had no information about the tiger disappearance from the Reserve. The percentage of known respondents was higher among the villages belonging to the other two categories i.e. 89.5% outside Core zone-I and 92.6% outside the Tiger Reserve. Regarding the extermination of tigers, a large percentage of the respondents from all the villages, (88.7%) category-I, (94.8%) category-II and (93.3%) category-III, felt that it was a sad happening with only a lesser percentage being happy with the fact. As whether the tigers should be reintroduced or not, inhabitants of Core zone I (98.1%) were found more willing to welcome the move of Forest Department to bring back tigers in Sariska.



**Table 5.7 List of plant species exploited by the Local people of different villages in Core zone I of Sariska Tiger Reserve**

S.No.	Village	Fuelwood	Grass species	Non-timber Forest Product (NTFP) and fodder
1	Umri	<i>Anogeissus pendula</i> & <i>Acacia leucophloea</i>	<i>Apluda mutica</i> & <i>Heteropogon contortus</i>	<i>Butea monosperma</i> , <i>Acacia catechu</i> , <i>Acacia leucophloea</i> , <i>Zizyphus mauritiana</i> , <i>Zizyphus nummularia</i> , <i>Capparis decidua</i> , Bamboo & <i>Phoenix sylvestris</i>
2	Haripura	<i>Anogeissus pendula</i> , <i>Acacia leucophloea</i> , <i>Zizyphus mauritiana</i> & <i>Acacia catechu</i>	<i>Apluda mutica</i> & <i>Heteropogon contortus</i>	<i>Butea monosperma</i> , <i>Phoenix sylvestris</i> , <i>Acacia catechu</i> , <i>Acacia leucophloea</i> , <i>Zizyphus nummularia</i> , <i>Capparis decidua</i> , Bamboo & <i>Zizyphus mauritiana</i>
3	Kankwari	<i>Anogeissus pendula</i> , <i>Acacia leucophloea</i> & <i>Acacia nilotica</i>	<i>Apluda mutica</i> & <i>Heteropogon contortus</i>	<i>Butea monosperma</i> , <i>Acacia catechu</i> , Bamboo, <i>Capparis decidua</i> , <i>Zizyphus mauritiana</i> , <i>Flacortia indica</i> & <i>Phoenix sylvestris</i>
4	Kiraska	<i>Anogeissus pendula</i> & <i>Acacia leucophloea</i>	<i>Apluda mutica</i> , <i>Heteropogon contortus</i> & <i>Chloris dolychostachya</i>	<i>Butea monosperma</i> , <i>Acacia catechu</i> , <i>Capparis decidua</i> , Bamboo, <i>Capparis deciduas</i> , <i>Flacortia indica</i> & <i>Zizyphus mauritiana</i>
5	Sukola	<i>Anogeissus pendula</i>	<i>Apluda mutica</i> & <i>Heteropogon contortus</i>	<i>Anogeissus pendula</i> , <i>Acacia catechu</i> , <i>Capparis decidua</i> & <i>Butea monosperma</i>
6	Dabli	<i>Anogeissus pendula</i> & <i>Boswellia serrata</i>	<i>Apluda mutica</i> & <i>Heteropogon contortus</i>	<i>Butea monosperma</i> , <i>Capparis decidua</i> & <i>Acacia catechu</i>
7	Rekhamala	<i>Anogeissus pendula</i> & <i>Acacia leucophloea</i>	<i>Apluda mutica</i> & <i>Heteropogon contortus</i>	<i>Butea monosperma</i> , <i>Acacia catechu</i> , <i>Capparis decidua</i> , <i>Zizyphus nummularia</i> & <i>Acacia leucophloea</i>
8	Lilunda	<i>Anogeissus pendula</i> & <i>Acacia leucophloea</i>	<i>Apluda mutica</i> & <i>Heteropogon contortus</i>	<i>Butea monosperma</i> , <i>Acacia catechu</i> , <i>Capparis decidua</i> , <i>Zizyphus mauritiana</i> & <i>Zizyphus nummularia</i>
9	Deori	<i>Anogeissus pendula</i> , <i>Acacia leucophloea</i> & <i>Dichrostachys cineria</i>	<i>Apluda mutica</i> & <i>Heteropogon contortus</i>	<i>Butea monosperma</i> , <i>Acacia catechu</i> , <i>Capparis decidua</i> , <i>Zizyphus mauritiana</i> , <i>Zizyphus nummularia</i> & <i>Phoenix sylvestris</i>
10	Rotkala	<i>Anogeissus pendula</i> , <i>Acacia leucophloea</i> & <i>Dichrostachys cineria</i>	<i>Apluda mutica</i> , <i>Heteropogon contortus</i> & <i>Chloris dolychostachya</i>	<i>Butea monosperma</i> , <i>Acacia catechu</i> , <i>Capparis decidua</i> & <i>Zizyphus nummularia</i>



Table 5.8 Details of fodder exploitation, milk production, land holdings and grazing distance of livestock in different villages of Core Zone-I of Sariska Tiger Reserve

S.No.	Village	Fodder exploited per day (kg)	Total milk produced per day in summer (litres)	Total milk produced per day in winter (litres)	Total land holdings (Bighas)	Grazing distance for livestock (km)
1	Umri	10030.4	159	526.5	4	4.3
2	Haripura	4012.7	130.5	348	0	2.9
3	Kankwadi	11954.2	493	1057	0	3.4
4	Kirashka	8935.9	278	931	0	3.3
5	Sukola	2736.0	101.5	328	3	4.0
6	Dabli	12171.9	174	625	60.5	2.5
7	Rekhamala	3757.5	88	365	41	4.5
8	Lilunda	2609.5	81	278	0	2.9
9	Deori	5658.0	400	473	106.5	1.5
10	Rotkala	3091.9	123	304	0	3.8

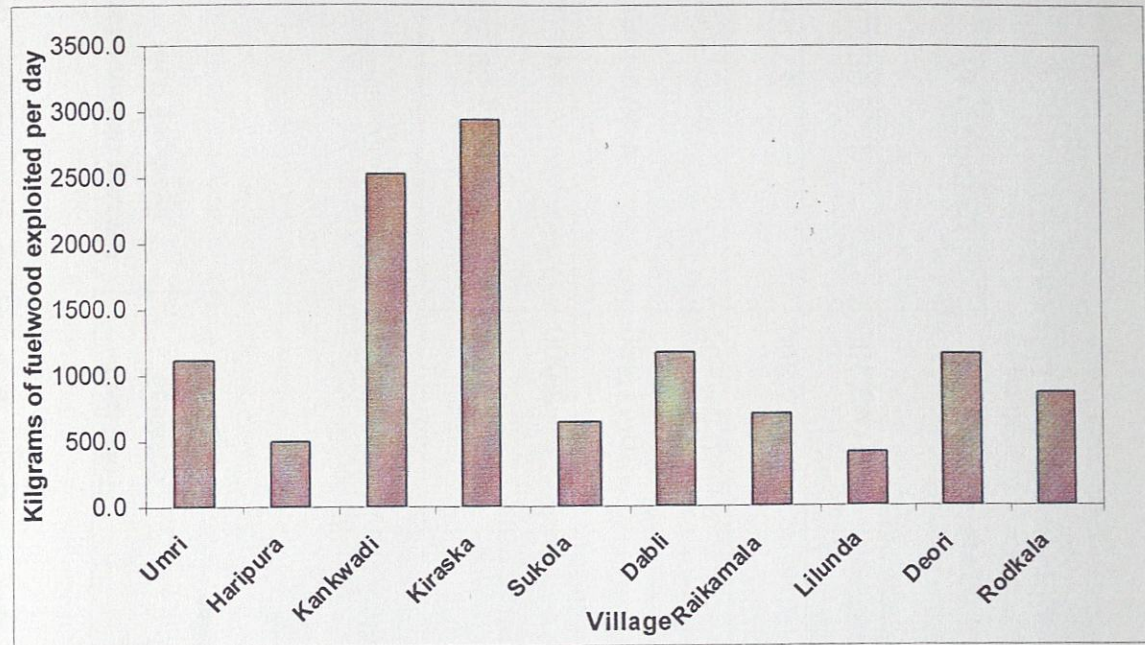
**Table 5.9 Details of commercial value of fuelwood and fodder exploited by people in Sariska Tiger Reserve**

Attributes	Category I	Category II	Category III	Category IV
<b>Quantity of fuelwood exploited annually (kg)</b>	49,69,700	1,08,98,900	19,43,100	1,58,68,500
Economic value of fuelwood exploited daily (Rs.)	7,300	15,900	2,800	23,100
Economic value of fuelwood exploited annually (Rs.)	26,09,100	57,21,900	10,20,100	83,31,000
<b>Quantity of fodder exploited annually (kg)</b>	2,63,07,900	1,90,06,400	16,41,400	4,53,14,400
Economic value of fuelwood exploited daily (Rs.)	8,400	6,100	2,000	14,600
Economic value of fodder exploited annually (Rs.)	30,40,000	21,96,300	7,18,100	52,36,300

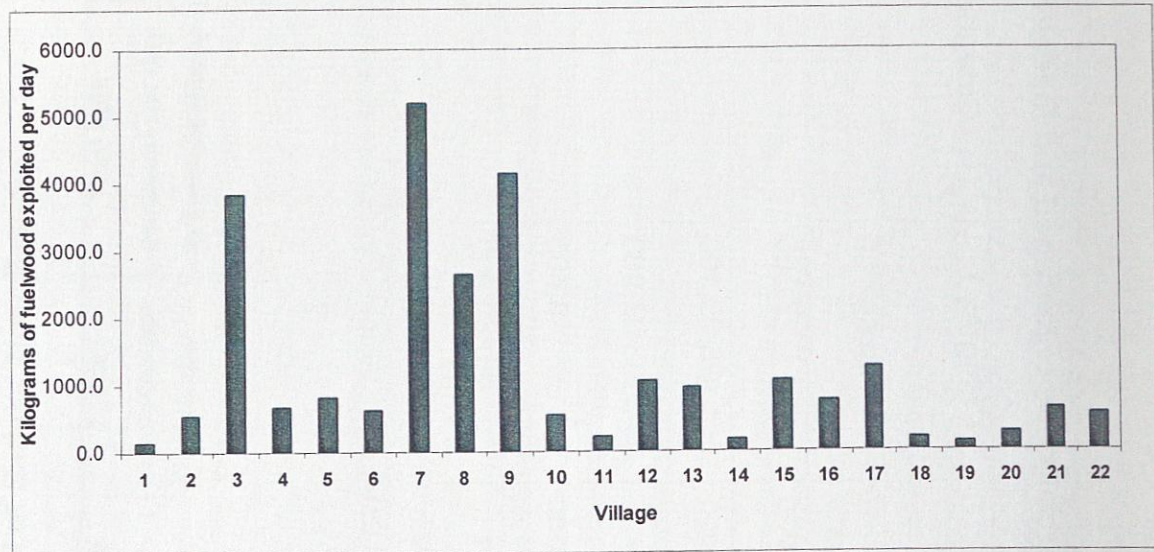
**Category I:** Villages in Core zone I **Category II:** Villages outside Core zone I but inside STR **Category III:** Villages outside STR **Category IV:** Villages combined in entire STR



**Figure 5.7** Quantity of fuelwood in kilograms exploited per day by the villages located in Core zone-I of Sariska Tiger Reserve



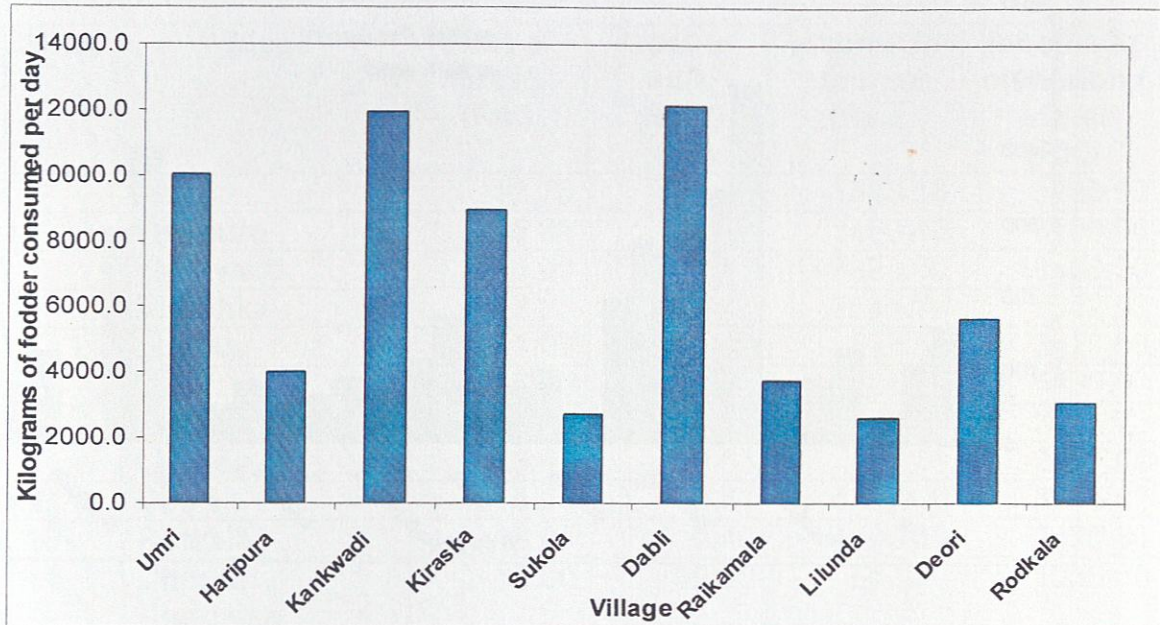
**Figure 5.8** Quantity of fuelwood in kilograms exploited per day by the other villages of Sariska Tiger Reserve (excluding Core Zone-I)



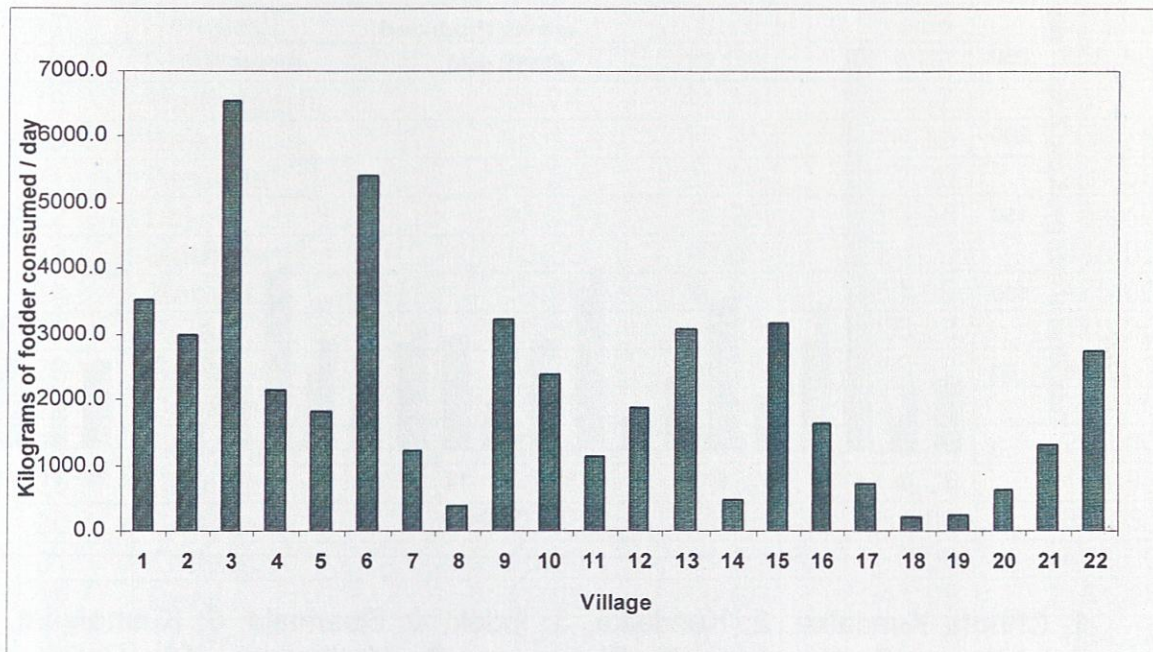
1; Chhota Kundalka, 2; Kundalka, 3; Indok, 4; Duarmala, 5; Kushalgarh, 6; Kalachhara, 7; Nangledi, 8; Bhairawas, 9; Madhogarh, 10; Raika, 11; Panidhal, 12; Loj, 13; Mathurawat, 14; Manyala, 15; Rajor, 16; Garh, 17; Dabkan, 18; Bhomighati, 19; Dhulawa, 20; Bandipul, 21; Thilwadi, 22; Bera



**Figure 5.9** Quantity of fodder in kilograms exploited per day for the livestock in villages located in Core zone-I of Sariska Tiger Reserve



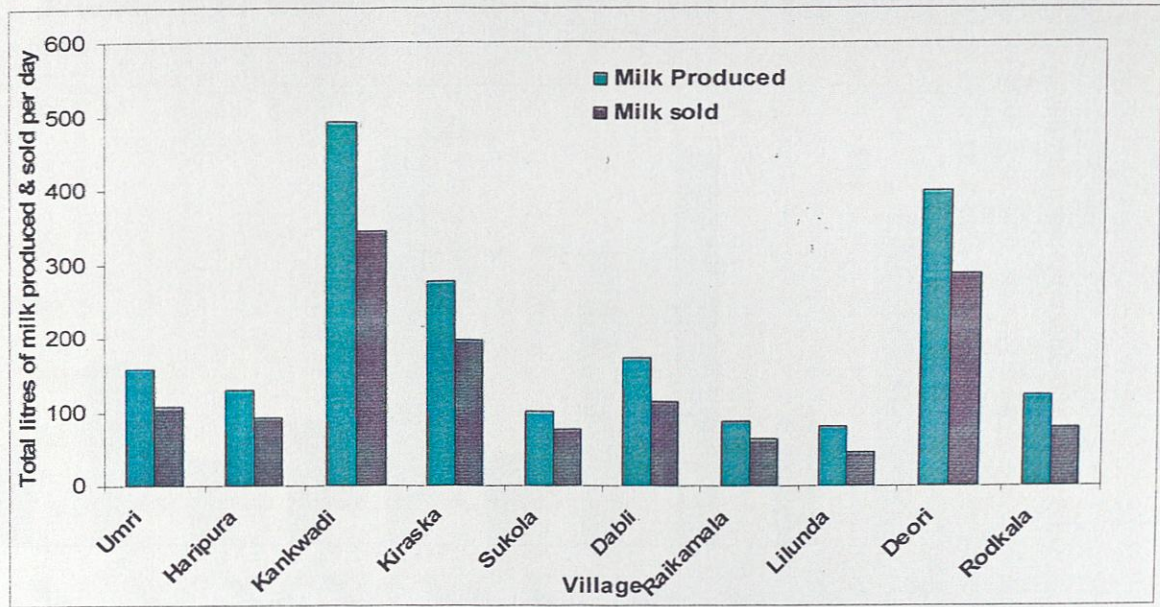
**Figure 5.10** Quantity of fodder in kilograms exploited for the livestock per day in other villages of Sariska Tiger Reserve (excluding Core Zone-I)



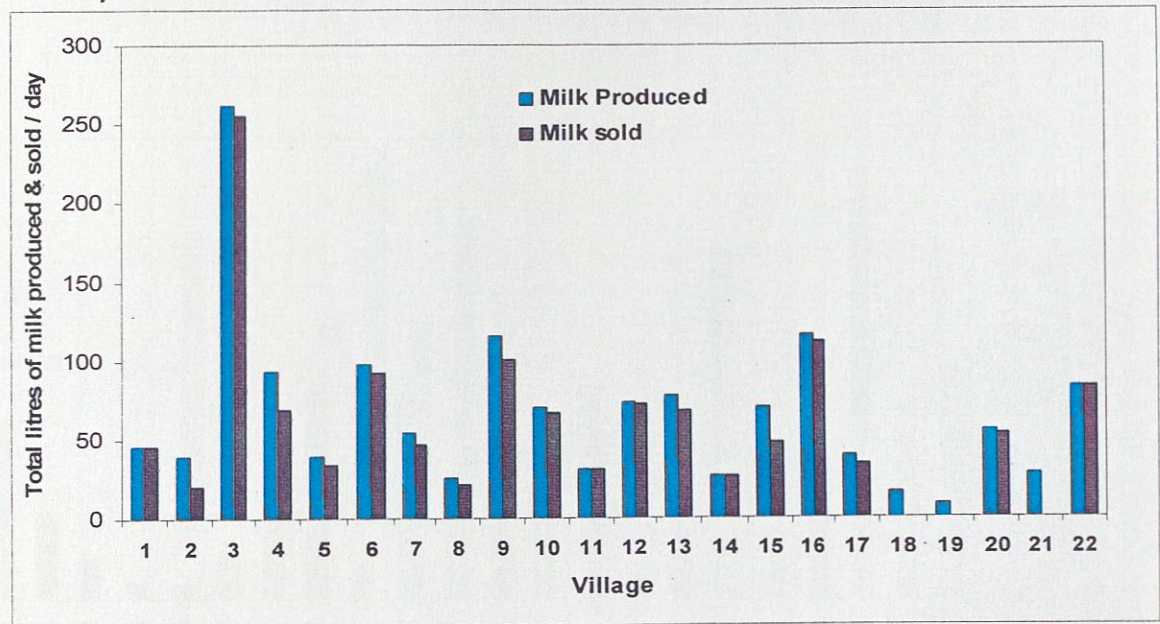
1; Chhota Kundalka, 2; Kundalka, 3; Indok, 4; Duarmala, 5; Kushalgarh, 6; Kalachhara, 7; Nangledi, 8; Bhairawas, 9; Madhogarh, 10; Raika, 11; Panidhal, 12; Loj, 13; Mathurawat, 14; Manyala, 15; Rajor, 16; Garh, 17; Dabkan, 18; Bhomighati, 19; Dhulawa, 20; Bandipul, 21; Thilwadi, 22; Bera



**Figure 5.11 Total liters of milk produced and sold among the sampled households in villages of Core zone-I of Sariska Tiger Reserve.**



**Figure 5.12 Total liters of milk produced and sold among the sampled households in other villages of Sariska Tiger Reserve (excluding Core Zone-I)**



1; Chhota Kundalka, 2; Kundalka, 3; Indok, 4; Duarmala, 5; Kushalgarh, 6; Kalachhara, 7; Nangledi, 8; Bhairawas, 9; Madhogarh, 10; Raika, 11; Panidhal, 12; Loj, 13; Mathurawat, 14; Manyala, 15; Rajor, 16; Garh, 17; Dabkan, 18; Bhomighati, 19; Dhulawa, 20; Bandipul, 21; Thilwadi, 22; Bera



Table 5.10 Income generations through selling milk in different villages surveyed in and around Sariska Tiger Reserve.

S.No.	Village	Cost of milk (S) (Rs.)	Cost of milk (M/W) (Rs.)	Income in summer (Rs.)	Income in monsoon / winter (Rs.)
1	Umri	12.75	11.00	1383.38	5236.00
2	Haripura	15.68	10.00	1450.40	3100.00
3	Kankwadi	16.00	11.50	5520.00	10453.50
4	Kirashka	12.83	10.62	2546.76	9042.93
5	Sukola	11.00	11.00	837.52	3327.50
6	Dabli	15.00	10.00	1725.00	5660.00
7	Rekhamala	13.50	10.53	864.00	3590.73
8	Lilunda	13.41	9.63	616.86	2340.09
9	Deori	15.00	10.82	4320.00	3906.02
10	Rotkala	13.81	9.49	1104.80	2476.89
11	Chhota Kundalka	12.00	10.00	552.00	1035.00
12	Kundalka	14.21	11.72	284.20	808.68
13	Indok	13.76	10.36	3508.80	5635.84
14	Duarmala	14.00	11.00	966.00	3014.00
15	Kushalgarh	13.46	9.59	457.64	704.87
16	Kalachhara	13.81	9.63	1277.43	2248.61
17	Nangledi	11.72	8.78	550.84	820.93
18	Bhairawas	14.17	11.00	304.66	566.50
19	Madhogarh	14.74	11.34	1481.37	2557.17
20	Raika	15.17	11.25	1016.39	2306.25
21	Panidhal	18.59	21.35	567.00	1921.50
22	Loj	13.32	10.26	959.04	2544.48
23	Mathrawat	13.00	10.00	884.00	1345.00
24	Manyala	13.00	10.00	351.00	475.00
25	Rajor	10.56	8.83	506.88	1470.20
26	Garh	12.73	11.28	1419.40	2347.37
27	Dabkan	18.35	12.56	623.90	1394.16
28	Bhomighati	12.00	10.00	0.00	200.00
29	Dhulawa	18.00	11.32	0.00	101.88
30	Bandipul	18.13	11.56	951.83	1300.50
31	Thilwadi	15.00	11.00	0.00	473.00
32	Bera	12.63	9.65	1041.98	2151.95
33	Thilwad	14.50	10.82	72.50	584.28
34	Chandpahari	11.43	10.00	394.34	820.00
35	Amrakabas	17.39	11.59	895.59	1303.88
36	Lawkabas	18.00	11.50	1575.00	1610.00
37	Manabas	17.43	11.48	427.04	585.48

(S: Summer, M: Monsoon, W: Winter)



Table 5.11 Reported Annual Income from different sources in different villages surveyed in Core zone-I of Sariska Tiger Reserve.

S.No.	Village	No. of Households	Annual Income From Different Sources (Rs.)					Per Household Average Gross Yearly Income (Rs.)	Per Household Expenditure on fodder purchased from market (Rs.)
			Milk Products (Rs.)	Agriculture (Rs.)	Work outside (Rs.)	Daily Wage Labour (Rs.)	Sale of Livestock (Rs.)		
1	Umri	50	42060	0	4678	0	1730	48470	28710
2	Haripura	35	40820	0	4368	0	2297	47485	28630
3	Kankwadi	91	56450	0	990	0	1846	59290	27025
4	Kirashka	111	42760	0	5845	0	3320	51928	27990
5	Sukola	30	31430	0	1125	0	1720	34270	15310
6	Dabli	46	53230	1400	987	0	3300	58920	10290
7	Rekhamala	35	77590	0	5220	0	880	83690	23985
8	Lilunda	20	30220	0	810	0	1000	32030	19400
9	Deori	65	40940	1590	2610	0	1905	47040	8450
10	Rotkala	38	38220	0	0	0	2560	40785	18375

Table 5.12 Annual Income from different sources in different villages surveyed outside Core zone-I of Sariska Tiger Reserve

S.No.	Village	No. of Households	Annual Income From Different Sources (Rs.)				Per Household Average Gross Yearly Income (Rs.)	Per Household Expenditure on fodder purchased from market (Rs.)	
			Milk Products (Rs.)	Agriculture (Rs.)	Work outside (Rs.)	Daily Wage Labour (Rs.)			Sale of Livestock (Rs.)
1	Chhota Kundalka	11	26910	0	10100	4410	632	42052	23805
2	Kundalka	35	7580	2398	11870	0	1278	12441	11823
3	Indok	230	11246	1353	12068	4610	1116	30395	10727
4	Duarmala	24	62310	0	0	0	1381	63694	8700
5	Kushalgarh	50	8150	920	0	4333	1000	14400	9545
6	Kalachhara	36	20565	0	0	0	753	22896	15396
7	Nangledi	250	5357	1865	7279	0	2409	16912	2814
8	Bhairawas	250	5469	0	9666	5716	592	21445	3920
9	Madhogarh	250	10096	920	3654	5898	1119	21692	10650
10	Raika	26	37568	0	0	0	840	38408	9954
11	Panidhal	11	39174	845	0	0	0	40020	19042
12	Loj	62	9707	0	3477	0	911	14096	2999
13	Mathrawat	48	8030	5765	6375	3256	1216	25168	7075
14	Manyala	12	11510	3100	0	0	466	15079	4987
15	Rajor	79	7180	3535	0	0	1553	12270	3139
16	Garh	43	20497	10580	9322	0	1843	42241	18029
17	Dabkan	55	8065	0	0	6282	1800	16147	3925
18	Bhomighati	9	4000	0	0	0	1000	5000	6375
19	Dhulawa	8	2290	4215	0	6975	0	13482	7218
20	Bandipul	15	25125	2210	0	0	0	27333	16292
21	Thilwadi	35	2580	2715	0	6339	1116	12749	908
22	Bera	40	14310	0	0	0	565	14872	12439
23	Thilwad	125	880	1700	4156	5085	1220	13046	6643
24	Chandpahari	55	7512	2575	2000	0	1900	13987	6653
25	Amrakabas	22	26360	3655	5578	0	1237	36830	19198
26	Lawkabas	50	10500	4045	8640	6277	2655	32118	4390
27	Manabas	40	5648	2596	9573	0	2033	19851	3713

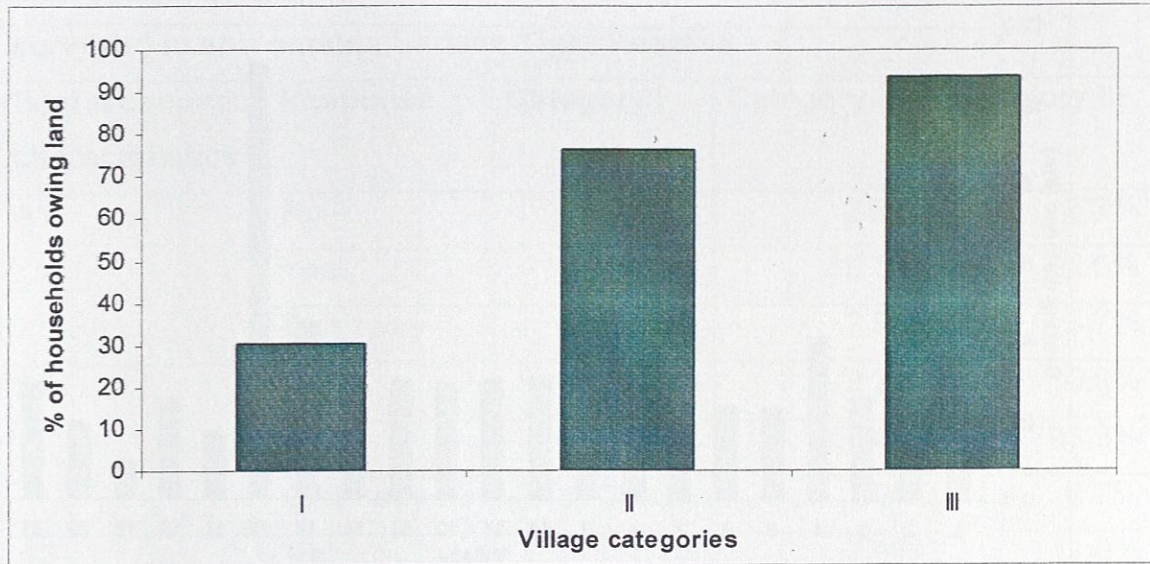


Table 5.13 Details of land holdings among different villages surveyed in and around Sariska Tiger Reserve

S.No.	Categories	No. of households sampled	Percentage of households owning land	No. of households owning land inside STR	No. of households owning land outside STR	Total area of land owned inside STR (bighas)	Total area of land owned outside STR (bighas)	Village owning maximum land	Village owning minimum land
1.	Villages in Core zone I of STR	275	30.55%	73	11	215	62.5	Deori	Sukola
2.	Villages outside Core zone I but inside STR	751	76.43%	562	12	1928.8	27	Indok	Panidhal
3.	Villages outside STR	163	93.87%	0	153	0	570.8	Lawkabas	Chandpahari



**Figure 5.13 Percent of households owned by villages surveyed in and around Sariska Tiger Reserve**



I; Villages in Core zone I of STR, II; Villages outside Core zone I but inside STR, III; Villages outside STR

**Figure 5.14 Average distance covered for grazing by the livestock in different villages in Core zone-I of Sariska Tiger Reserve**

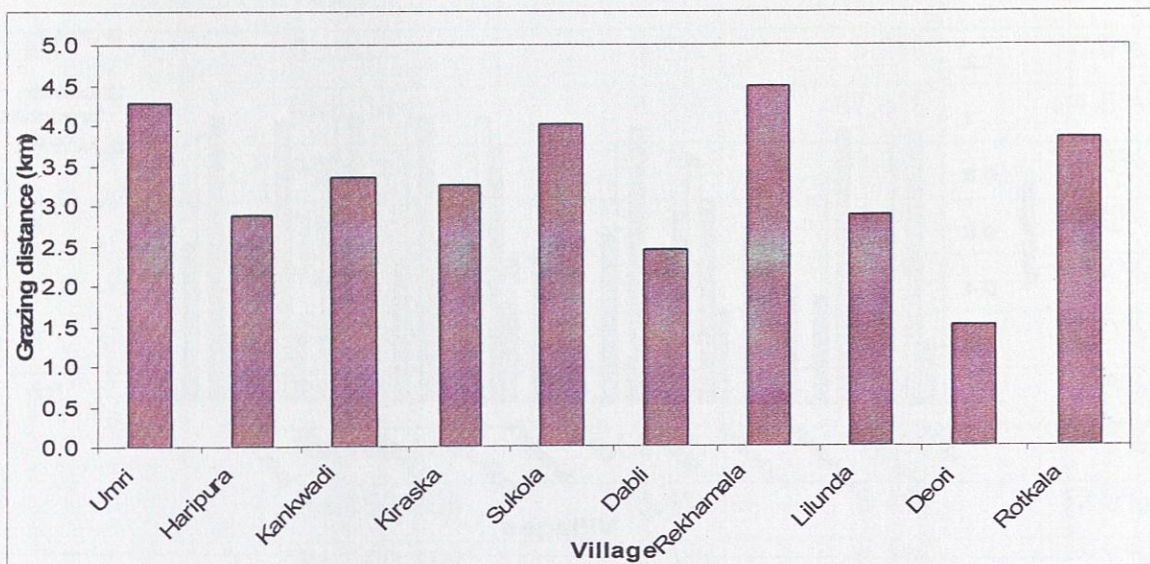
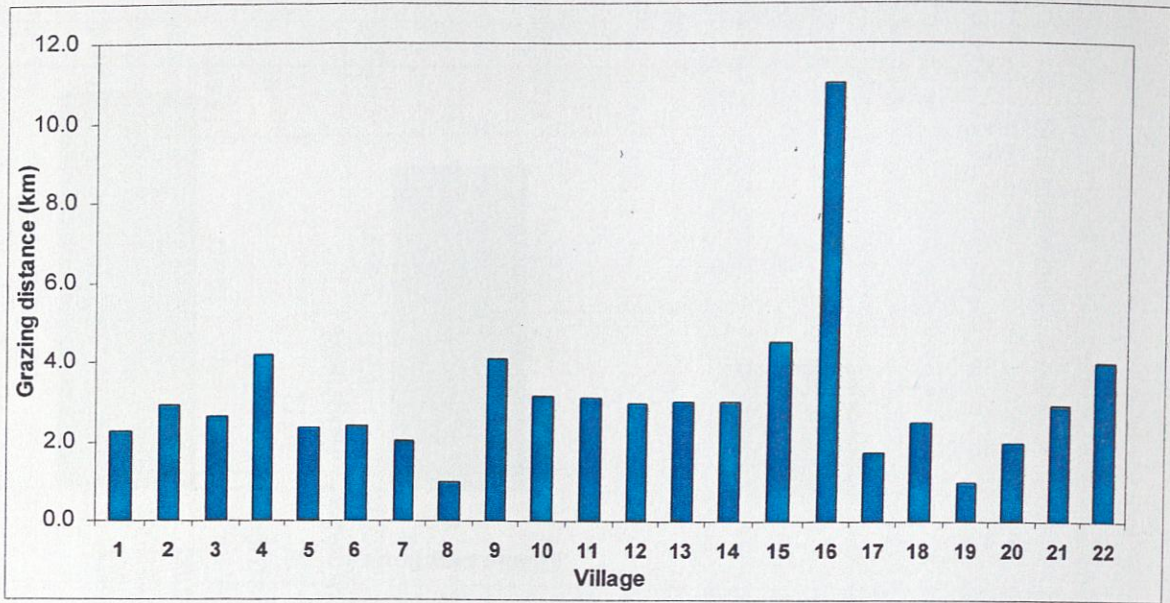


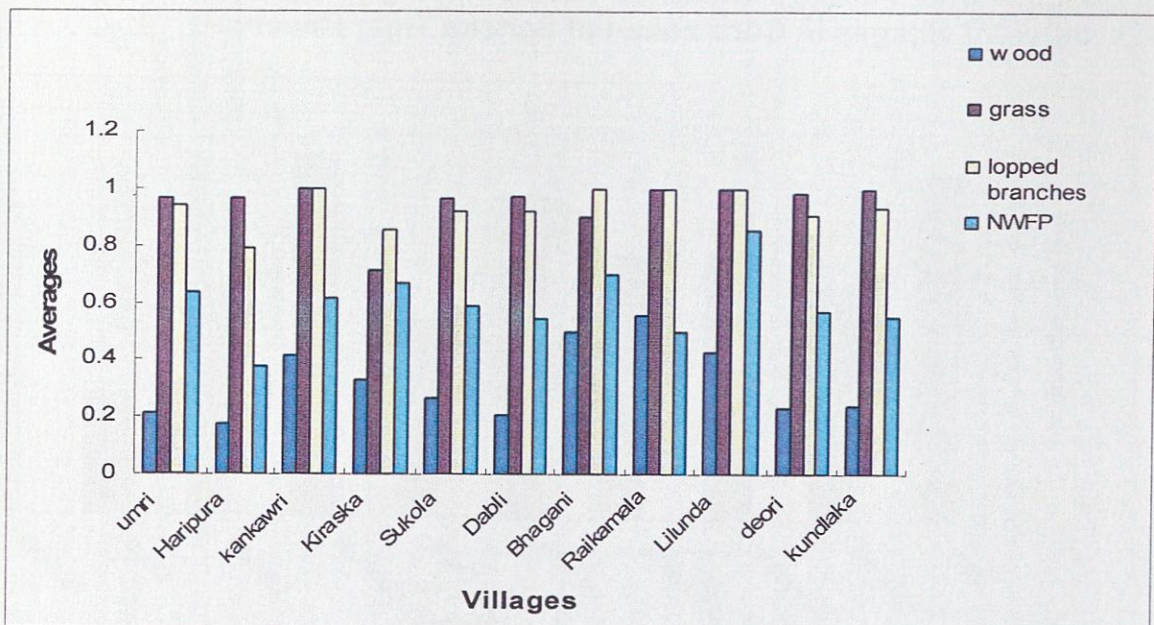


Figure 5.15 Average distance covered for grazing by the livestock in other villages of Sariska Tiger Reserve



1; Chhota Kundalka, 2; Kundalka, 3; Indok, 4; Duarmala, 5; Kushalgarh, 6; Kalachhara, 7; Nangledi, 8; Bhairawas, 9; Madhogarh, 10; Raika, 11; Panidhal, 12; Loj, 13; Mathurawat, 14; Manyala, 15; Rajor, 16; Garh, 17; Dabkan, 18; Bhomighati, 19; Dhulawa, 20; Bandipul, 21; Thilwadi, 22; Bera

Figure 5.16 Different anthropogenic factors reported from 11 villages of Core-1 in Sariska Tiger Reserve.





**Table 5.14 Percentage of respondents to various socioeconomic and awareness questions in three different categories of the villages surveyed in and outside Sariska Tiger Reserve**

Socioeconomic characteristics	Response	Category I	Category II	Category III
A1	No	13.2%	2.6%	3.7%
	Yes	78.9%	89.5%	92.6%
	Can't say	7.9%	7.9%	3.7%
A2	No	10.5%	2.3%	0.0%
	Yes	88.7%	94.8%	93.3%
	Can't say	3%	3.0%	6.7%
A3	No	1.1%	7.1%	11.0%
	Yes	98.1%	80.5%	83.4%
	Can't say	0.8%	9.4%	5.5%
A4	No	36.1%	96.4%	100.0%
	Yes	60.9%	3.6%	0.0%
	Can't say	3.0%	0.0%	0.0%
A5	No	97.0%	70.8%	44.2%
	Yes	3.0%	29.2%	55.8%
A6	Good	3.8%	3.2%	0.0%
	Indifferent	78.6%	87.5%	94.5%
	Against	17.7%	9.3%	5.5%
A7	No	30.8%	27.7%	8.6%
	Yes	66.9%	71.8%	91.4%
	Can't say	2.3%	0.5%	0.0%
A8	Rs.0.0	32.3%	28.2%	8.6%
	Rs.100-150	50.0%	71.1%	77.3%
	Rs.150-200	15.4%	0.4%	12.9%
	Rs.200-300	2.3%	0.3%	1.2%

(cont'd)



Socioeconomic characteristics	Response	Category I	Category II	Category III
Willingness to relocate	No	0.8%	NA	NA
	Yes	57.9%	NA	NA
	Yes, if	39.5%	NA	NA
	Can't say	1.9%	NA	NA
Human leopard conflict	No	99.2%	100.0%	100.0%
	Yes	0.8%	0.0%	0.0%
	Can't say	0.0%	0.0%	0.0%
Livestock leopard injury	No	86.9%	18.3%	46.0%
	Yes	13.1%	81.7%	54.0%
	Can't say	0.0%	0.0%	0.0%
Crop raiding	No	75.0%	9.5%	0.0%
	Yes	25.0%	90.5%	100.0%
	Can't say	0.0%	0.0%	0.0%

**Category I:** Villages in Core zone I of the Tiger Reserve

**Category II:** Villages outside Core zone I but inside STR

**Category III:** Villages outside STR

**A1:** Do they know that tigers have disappeared?

**A2:** Is it bad to have no tigers?

**A3:** Should the tigers be brought back?

**A4:** Does their wood extraction harms the forest?

**A5:** Has Government helped them in any way?

**A6:** Perception towards Forest Department?

**A7:** Will they prefer to use LPG?

**A8:** How much they can pay for it per month?

**NA:** Not Applicable



Figure 5. 17 Intensity of wood cutting in Sariska Tiger Reserve

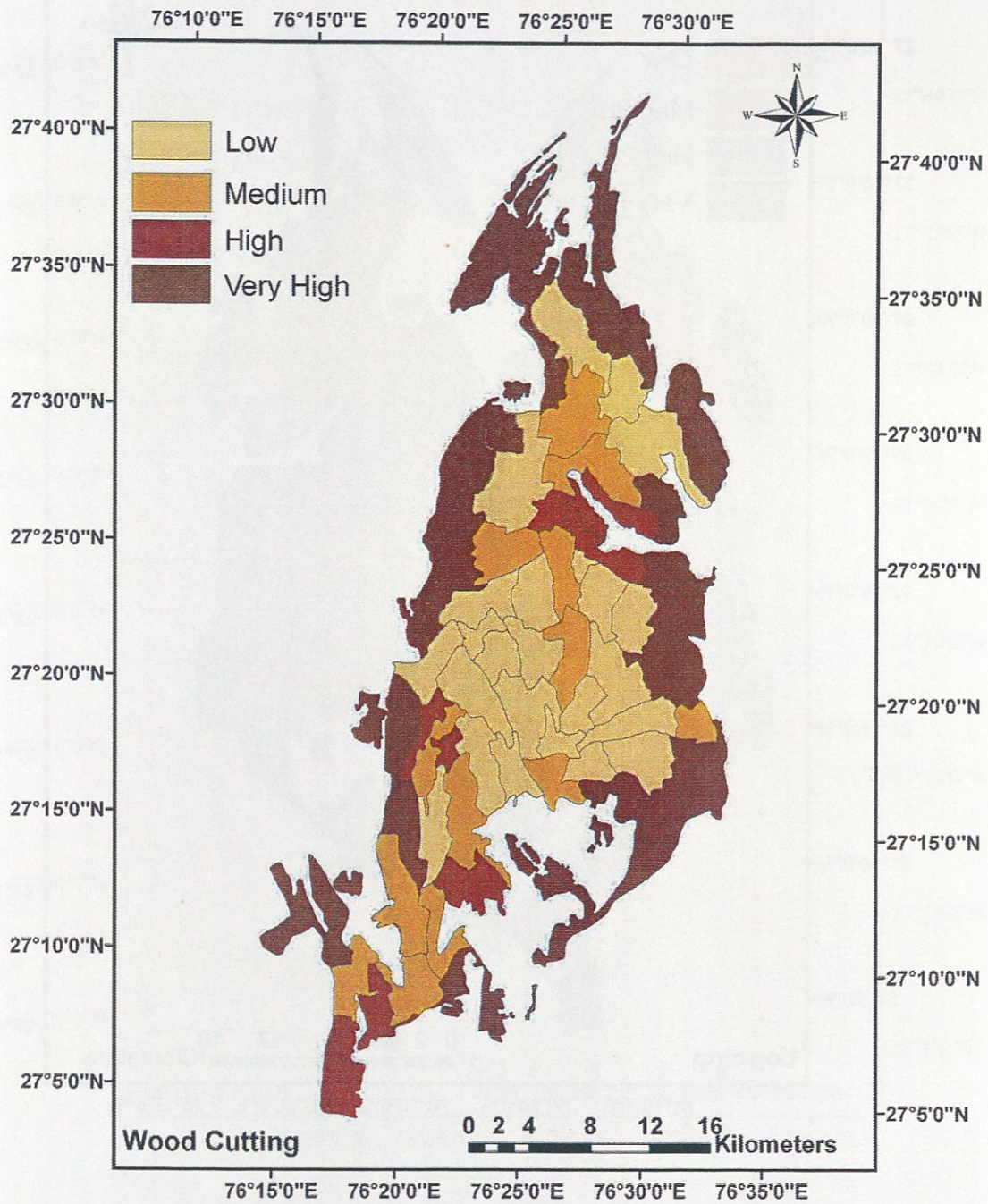




Figure 5. 18 Intensity of lopping in Sariska Tiger Reserve

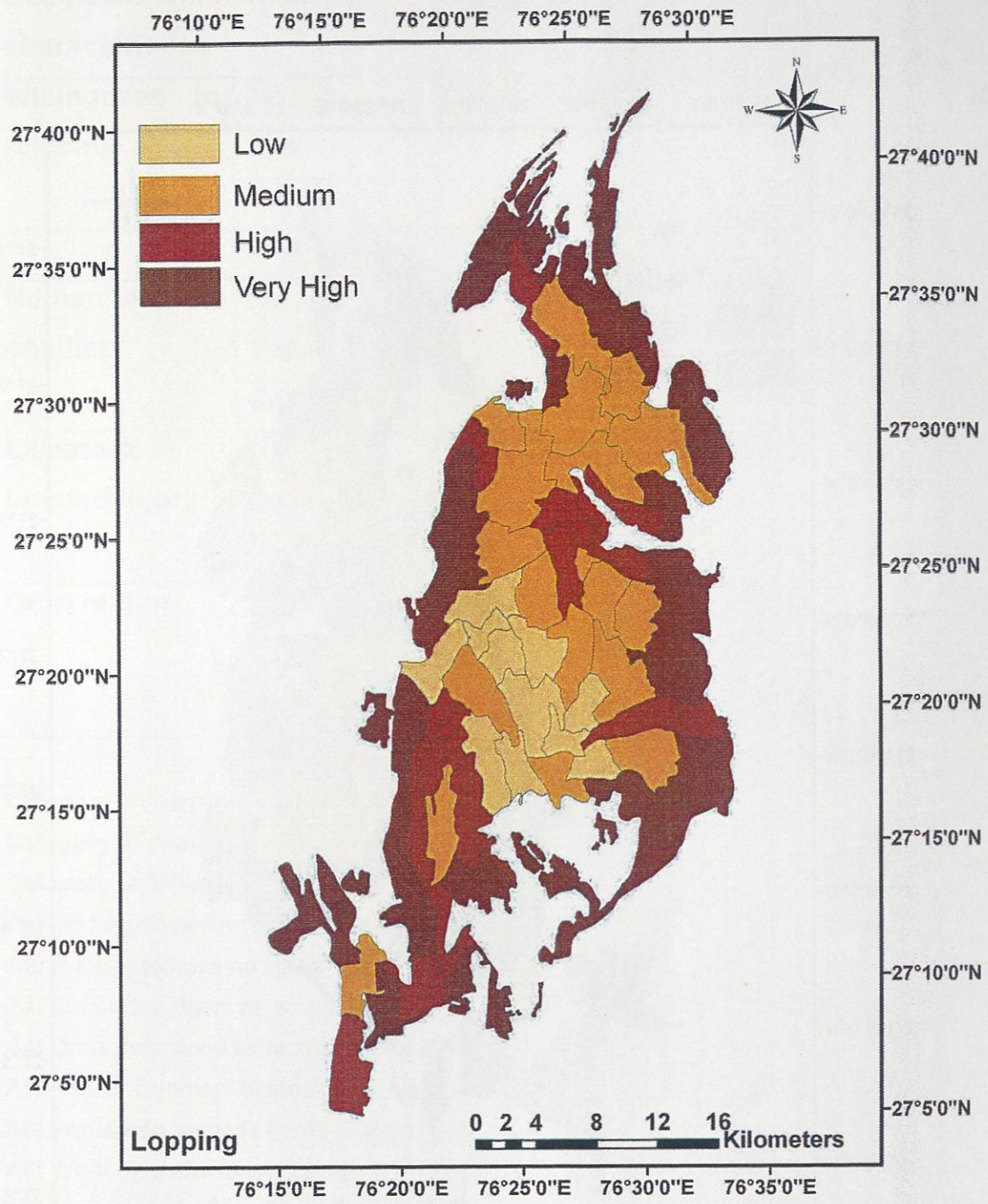




Figure 5. 19 Intensity of grazing in Sariska Tiger Reserve

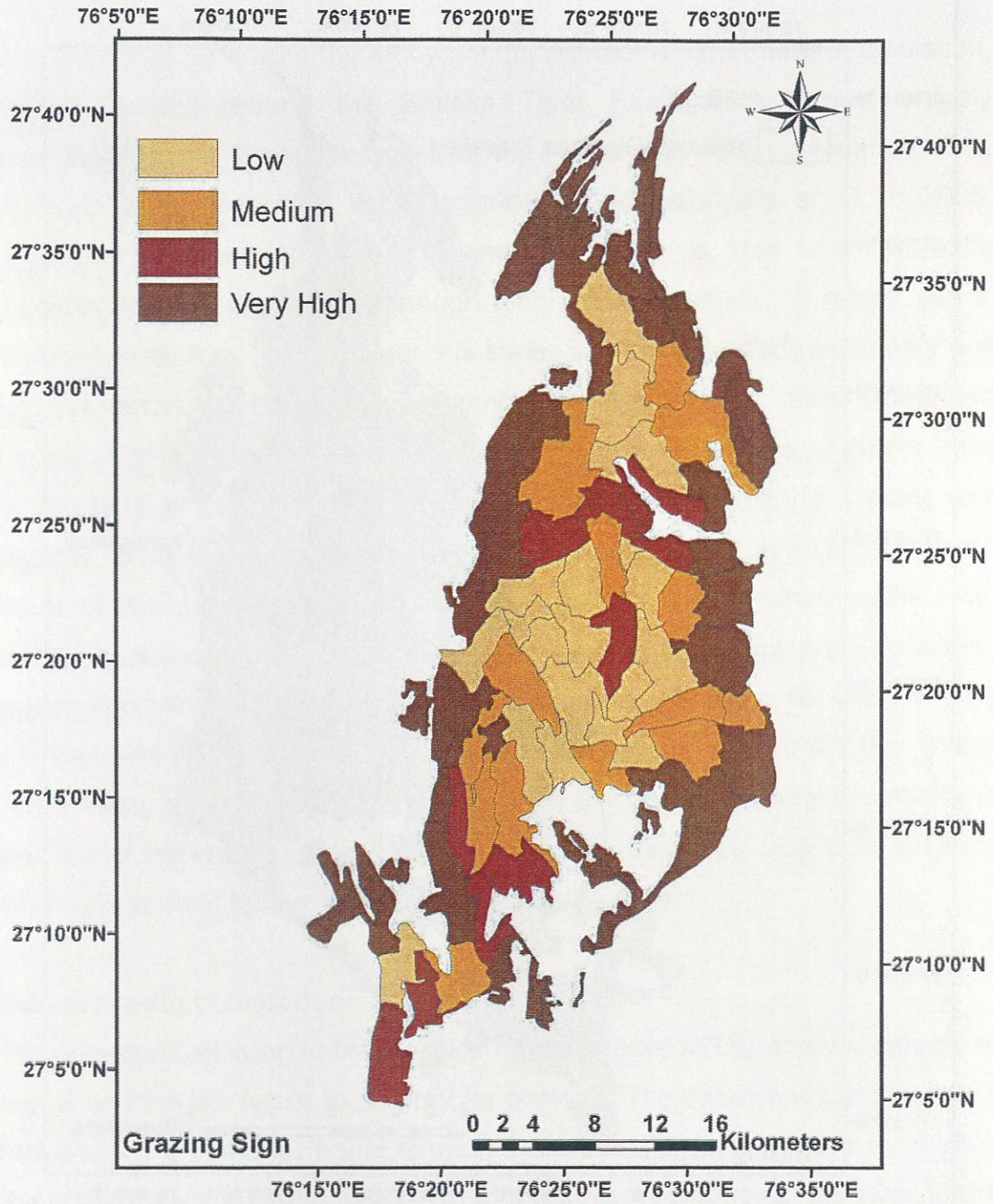
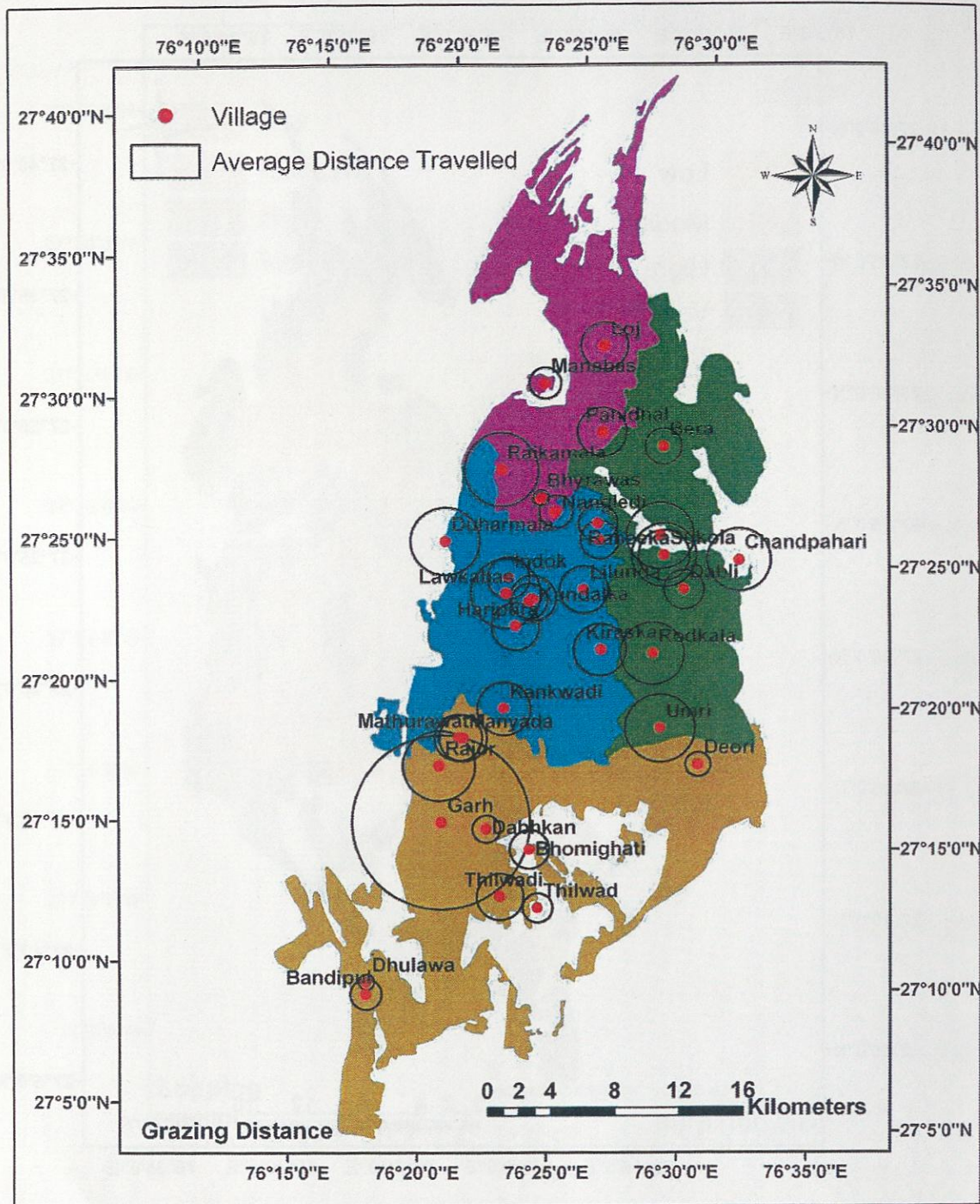




Figure 5. 20 Livestock grazing influence zones around each village in Sariska Tiger Reserve





## 5. 5 DISCUSSION

As is clearly evident from the study conducted that a large human population, residing in and around the Sariska Tiger Reserve, is almost entirely dependent on the forest resources of the Reserve for the sustenance of its livelihood which has also been reported by Shahabuddin *et al.* in 2005. Consequently, there appears an immediate need to look into the entire scenario as early as possible through different approaches. In recent years, the Governments of India and various states are making efforts to identify and address conservation and local community needs in a more integrated manner. The key to successful conservation is making sure communities have access to a wider menu of development options in addition to sharing any benefits of biodiversity conservation while not carrying a disproportionate share of the costs. All over the world, economic benefit-sharing with local people, sustainable use options, community-based protection and democratic co-management are being experimented with, as ways to improve the effectiveness of wildlife conservation, a paradigm shift that the Indian bureaucracy seems to be resistant to. Such a shift has become imperative in the face of increasing evidence that the “fences-and-fines” approach is failing miserably in most Indian Tiger Reserves (MoEF 2005).

### **Forest product collection:**

The communities living in the Sariska Tiger Reserve (STR) depend entirely on fuelwood from the forest for energy for cooking. The extensively large amount of fuelwood and fodder being extracted from the Reserve seems to result in the quick depletion and degradation of the forest resources in the near future. Long-term use of the Sariska forests for grazing, fodder collection and firewood removal by local residents has been reported as the primary cause for degradation and biodiversity loss (Shahabuddin 2005). Extensive forest degradation in certain regions suggests that the intensive use of forests for sustenance and consumption is no longer viable (Davidar *et al.* 2007). The assumption that fuelwood and fodder extraction leads to deforestation has so far been the dominant mainstream view in deforestation discourses accepted by researchers, state agencies and conservationists (Nagothu 2001). Non-



Timber Forest Product extraction contributes significantly to local household income in tropical regions and has been viewed as preferable to conversion to other land uses when it is sustainable. However, non-sustainable resource extraction can have deleterious consequences for biodiversity and affect the livelihoods of the users (Davidar, *et al.* 2007). Though in Sariska the non-timber forest products do not contribute much to the income of the local people but their extraction is an important activity practiced to feed their livestock.

The fodder and fuelwood exploited, when estimated for their commercial values possess extremely high economic value in the market at local as well as national level. Also, these include the input costs that are being provided for the maintenance of the Tiger Reserve by the Forest Department and the State Government from time to time. Therefore, an invisible process of pauperization (Jodha 1990c) is developing as the costs of production (largely the time of the rural poor) from common resources increase and their outputs decrease. The overall variety and quality of products are declining (Jodha 1985b; 1992). Sustainable extraction can be achieved only under particular conditions of low population density, simple technology, localised resources and limited possibilities of expansion (Hames 1987 and 1991, Johnson 1989 and Stearman & Redford 1992). Collection for subsistence livelihoods could be a major driver of deforestation although the relationship between deforestation and wealth is not straightforward (Angelsen & Kaimowitz 1999 and Cropper & Griffiths 1994). Deforestation has multiple scalable causes that differ geographically (Godoy, *et al.* 1997 and Giest & Lambin 2002), suggesting that policy might have to be site and case-centric to be effective.

#### **Source of income:**

The local residents mainly depend on the sale of dairy products i.e. milk, *mawa*, *ghee*, etc. to earn their livelihoods. During the monsoon period, when milk production is the highest, the villagers earn and save money for the whole year as during summer milk production is extremely low as reported above. The profit gained by selling milk is also not of good extent as they don't sell it to the larger markets, but to the dealer in the village itself. The



local people, apart from a smaller percentage generally don't prefer to work outside. The fact can firstly be attributed to the illiteracy prevailing among them due to which they do not get work outside other than as daily wage labourers for which they are paid a mere amount of Rs. 2500 to 3000 per month and also they reported to have nobody to look after their family in their absence, most of them having young children, land and cattle, etc. Also, in villages like Sukola, Dabli and Rekhamala, the inaccessibility to roads due to which they have to walk down about 7 to 8 km even to visit a doctor, seems to be the major factor for the same and making them survive in extremely miserable conditions. As obvious, due to the location of the villages, highest percentage of people working outside was reported from the villages outside the Tiger Reserve. The people living here have a fairly good accessibility to roads and better opportunities to attain high level education.

The least income generation through agricultural practices for Core zone-I villages can undoubtedly be attributed to almost negligible land holdings with them except some in Dabli and Deori. People from Kiraska reported to own land in the earlier times. The major crops grown in these villages are wheat, oat, barley, and vegetables, etc. and out of the total yield half is sold and the rest half is kept for their own consumption. Other villages which earn comparatively more from agriculture have appreciable amount of land holdings and also better accessibility to other resources thus helping them in practising cultivation.

As discussed earlier, all families raising goats in the study area reported that they sell goats once or twice a year. According to Rathore 1993, the market in arid areas has been described as favouring the herder and good prices are usually available for most small holders except during drought years when desperation sales allow the buyer to set the price. Even then, goat sales are one of the few avenues of access to capital. Throughout the year goats provide the steadiest and most reliable source of income for non-specialist households in STR. This is especially significant in a region where failures in monsoon rainfall are common and agricultural production is highly risky (Robbins 1994). Also, goats are much hardier and able to subsist on browse



species. Additionally goats require next to no medical attention or commercial fodder in comparison to larger livestock (Shahabuddin *et al.* 2005).

#### **Level of education:**

The reported literacy rate was in accordance with the accessibility of schools inside or nearby the surveyed villages. The low literacy rate reported through the study can be attributed to very less accessibility to schools, especially for the villages like Sukola, Dabli, Rotkala and Rekhamala with no connectivity to nearby townships, the uncertainty of the teachers coming to the schools as they have to cover longer distances on foot to reach the villages and last but not the least lack of interest and awareness towards the value of education. Though the overall literacy rate reported for the Core zone-I villages was higher than the villages in the Reserve outside Core zone- I, the adult literacy was lower as far as the Core zone-I villages were concerned and higher among the residents of villages outside Core zone-I. The trend clearly showed that in the Core zone-I villages, the education remains restricted upto primary level only which is available to them within the village itself through the Government run Rajkiya Baudhshalas and after that it is discontinued in most of the families except some reported in Kiraska and Indok where some children are sent to Thanaghazi for higher education. On the contrary, outside inhabiting villagers do not restrict their education to primary level and try to approach farther places to get education, if possible. The same reason can be attributed to even higher literacy rate among the inhabitants of villages located outside the Tiger Reserve with even much higher literacy rate among the adults as compared to children. These people go to Alwar, Tehla and Thanaghazi to acquire higher education.

#### **Ongoing Government schemes:**

In some villages like Garh, Bhomighati, Dhulawa, Mathurawat and a few others, solar lights have been distributed to every household at low prices of Rs. 1500, which actually costs high at about Rs. 7000 in the market. The villagers are also provided with BPL cards (Below Poverty Line cards) with which the inhabitants can avail cereals and other food items at extremely low rates but according to the study conducted the distribution was not at all



uniform and most of the BPL cards were found to be owned by rich families rather than the poor ones. Also, the Government has made a provision of temporary employment to the villagers through various schemes, 'Guarantee Rozgar Yojna' being one among them where these villagers are made to dig the *Jodas* for the Forest Department and paid at the rate of Rs. 70 to 103 per day. Primary schools (*Prathamik Baudhshalas*) in almost all the villages and secondary schools in some are one of the best government programmes being run in the entire Tiger Reserve and even in the surrounding villages. Further more, as reported by some villages like Thilwad, the Government also facilitates the supply of vaccines/medicines for their livestock.

**Livestock grazing distance:**

As from all the villages, livestock are taken for grazing to the forest upto distances varying for all three village categories and even for each village. It is evident that there is very less undisturbed wildlife habitat left (<15%) in the notified National Park area (Core Zone-I) and also in the entire Tiger Reserve (Figure 5. 20 & 5. 21).

**Anthropogenic pressure:**

Studies on carnivores have reported an increase in exploratory movements by them due to changes in level of disturbance and habitat conditions (Griffiths and Van Schaik 1992). Such exploratory movements of tigers in Sariska probably made them more vulnerable to poaching. Mammalian carnivores are characterized by classic relationship with their prey. It seems that carnivores are closely tied with prey size, prey biomass and disturbance factors (Karanth and Nichols, 1998; Carbone and Gittleman 2002; Seidensticker *et al.* 1990). Prey density is critical to maintenance of large carnivore population. Looking at current socio-political scenario it is important to maintain core-breeding areas for tigers and leopards at landscape level. In any given National Park, it is important to maintain mini-cores as a source area for large carnivores and its prey. In Sariska Tiger Reserve, the Sariska-Pandupole valley (ca. 80 km<sup>2</sup>) is the only area, which can be considered as mini-core. The reported presence of breeding tigers in this area indicate relatively undisturbed core. As the rest of the park area

is disturbed due to anthropogenic pressures they have very low wild ungulate density and hence it can support only a few tigers (Johnsingh *et al.* 1997). The future of tiger population was reported to be insecure due to immense biotic pressure caused by human and livestock population (Johnsingh *et al.* 1997). There are two state highways: the Alwar-Thanaganazi-Jaipur and Sariska-Kalighati-Tehla, which are over 44 km in length traversing through the National Park. The vehicular traffic and the resulting pollution and noise cause enormous disturbance to wildlife (Johnsingh *et al.* 1997). Mining, particularly for dolomite, is a serious problem in the southern part of the Tiger Reserve, threatening the habitat in the Reserve. Ten villages located in this area are due for relocation since 1984 (Sankar 1994, Johnsingh *et al.* 1997). Johnsingh *et al.* (1997) reported that part of National Park (ca.120 km<sup>2</sup>) could sustain a high density of prey species and a reasonable population of tigers. The future of tiger reintroduction program in Sariska will also depend on the human interference free habitat in Core Zone-I, which is necessary for tiger breeding and reproduction.

#### **Extent of awareness and attitude towards conservation:**

The study revealed a mixed pattern in local attitudes towards conservation. For the inhabitants of Core zone-I, the inaccessibility to the outside world and fewer opportunities to avail the facilities of the developing world, education, etc. can be attributed to their lesser knowledge regarding their surroundings i.e. tiger extermination etc. The inhabitants almost from every village category had beliefs that the presence of tigers in the Reserve kept their livestock healthy as the killing of one cattle by the tiger stopped the spread of diseases among their entire livestock population. Some people, in fact, said that tigers play an important role in the grazing economy through their depredations on livestock as tigers tend to cull out the weaker individuals from the stock. Alves (1999) also reports a local folk proverb: 'The tiger and the cow must drink from the same pool' and a common belief that 'because of the tiger, the buffalo is not sick too often', reflecting the perceived importance of the tiger in the grazing economy. Also, the respondents were really keen and willing



regarding tiger reintroduction and responded through facts which really showed their positive and caring attitude towards environment and conservation. They said that tigers are 'king of the jungle', it is their home and they should definitely live in their natural habitats. Also, they reported that tigers safeguard the forests from resource exploitation as people are afraid of going into the interiors of the forest for fuelwood and fodder collection as compared to now days when even their young children take their cattle for grazing. Most of the Government employment schemes were reported in the villages outside Core Zone-I and even outside the Tiger Reserve which, resulted in a negative perception of the respondents towards the Government authorities. Also, maximum inhabitants reported the Forest Department to be indifferent in charging them fine for cattle grazing and not allowing them to bring fuelwood and fodder from the forest.

The inhabitants in Core zone-I had mixed views for using LPG as a substitute for fuelwood as the people against its use said why to waste money when fuelwood is freely available while others were ready to pay about Rs.100 - 150 per month for the same. This showed their instrumental attitude towards the environment and unaware of the conservational values of the forests resources and natural habitats. On the other hand, inhabitants from outside Core zone I and outside the Tiger Reserve were more willing for LPG use and also more people were ready to pay Rs.100 to 150, with some even Rs. 150 to 200 and Rs. 200 to 300. This can directly be related to their higher level of education, better livelihood conditions and appreciable awareness towards nature conservation.

The response regarding relocation varied with the education level, accessibility to the essential commodities, sources to earn livelihood, etc. None of the villagers had any idea of rotational grazing policy required for sustainable utilization of available resources. Everybody seemed to be in a hurry to finish off the forest resources as they feared of being relocated outside Sariska anytime. After the successful relocation of Bhagani, the Forest Department is now preparing the blue print for the relocation of Kankwadi, Umri, Haripura and Kiraska in the near future. The inhabitants of

Core zone I really showed positive response towards the relocation plan provided they are dealt fairly and shifted outside Sariska with a good deal to people (land for cultivation, money, house, water, electricity and easy accessibility to a nearby town to avail banking, medication and educational facilities). Some people also demanded legal papers for the land given for which they were also ready to sign a bond for not selling it for the next twenty years. It seems that other villages would also follow the relocation path if similar deal is given to them like the one offered to Bhagani villagers and their requirements are fulfilled to satisfactory levels. The villagers from Haripura do not want to be shifted outside Sariska and rather demand electricity to their village. This was because of the reason that Haripura is located close to the human habitation (Forest Department head quarters and Bhartari) and close to Alwar-Thanghazi, Alwar-Tehla main roads. The future of Sariska lies in successful relocation of the remaining 10 villages from the notified area of the National Park (Core Zone-I), which in turn will provide a disturbance free habitat for the wild ungulates and their predators.

The negligible incidents reporting human-leopard conflict can also be attributed to the eco-friendly attitude of the respondents, wherever found. But on the contrary, livestock-leopard conflict reported to a much greater extent could be responsible for their non-conservationist attitude. The non-friendly behaviour of the villagers inhabiting Core zone I or outside Core Zone-I and outside the Tiger Reserve can also be partly attributed to the losses they face in their crop fields by the wild animals. Crop raiding by the wild ungulates especially wild pigs, nilgai, sambar and chital was reported by the villagers from almost all the villages inside and outside the Tiger Reserve.

#### **Recommendations:**

Large-scale development of plantations, pastures and forests is required in the Buffer Zone of Sariska and beyond, to reduce pressures on Core Zone-I plant biomass. Positive interactions have to be inculcated between peripheral villages and reserve management via substantial compensatory mechanisms such as for loss of access to forest resources and compensation for injuries and crop-raiding by wild animals. Co-management of forests involving local



people and institutions, and restoration of their rights may help to resolve conflicts related to resource use and lead to a better management of natural resources. It is said that introducing 'real' people-oriented management approaches are the way to achieve long-term biodiversity, thus more site-specific and human-faced park management policies are needed, particularly provision of tangible benefits and alternative livelihoods for the affected population (Lai Ming Lam 2004). We recommend the following steps to be taken in achieving a sound and successful conservation and management programme.

(i) **Planning proper relocation programs:** The relocations should be planned in a way so that it should be equally beneficial to the local communities and to the organizations planning them. Also, it should be fair and fulfilling the livelihood requirements of the communities concerned because planning resettlements in a wrong way can be even more detrimental to park management as it would discourage long term resource management by the local people. But the same if planned keeping safe the local people's social, cultural and economic interests will definitely gain the trust and support of the communities which will be beneficial to continue the relocation programmes on a long term basis and in a more effective manner.

(ii) **Provision of alternative sources for fuelwood for villages in the Sanctuary:** It is clearly evident that the villages outside Core Zone-I are also equally dependent on the forests of STR for their daily fuelwood requirements. Therefore, to prevent them from continuing the exploitation of the forest resources after relocation of Core Zone-I villages, it is necessary to make provisions for alternatives of fuelwood like LPG, Biogas, etc. and conserve the biodiversity on a long term basis.

(iii) **Provision of bank loans for people living in the Sanctuary:** It is also observed that the average household economy subsists on milk sales, therefore the provision of bank loans through different schemes to the people living in the Sanctuary i.e. outside Core Zone-I should be made so as to



increase their annual household income and in turn reduce the pressure on the Tiger Reserve.

(iv) **Education Programs:** Education among the masses has always proven helpful in achieving the most efficient plans in any field of management and conservation. Given asymmetries of costs and benefits, these are not expected to work in isolation to the park or people conflicts, but may also be necessary in all or most cases.

(v) **Wildlife extension programs:** Awareness programs should be launched through different Government and non-Government organizations to make the local people understand the value and importance of their surroundings because without the cooperation of local communities at places where these protected areas are an important part of their livelihood, achieving conservation goals seems to be difficult and that protected areas cannot exist in isolation. There is a critical link between development and conservation and National Parks are well placed to encourage sustainable living in the surrounding communities. Therefore, the authorities need to recognize the links with and dependence of local communities with their surroundings to and wherever possible facilitate community development to encourage them to actively participate in the conservation plans.

(vi) **Provision of alternative livelihood sources:** The presence of alternatives not only influences people's acceptance of the Protected Area, which is crucial to ensure the future viability of the Protected Area, but also reduces the dependence of the people on the Protected Area. Therefore, provisions of alternative sources of employment are necessary for the long-term survival of the Park.

(vii) **Extension of medical facilities to the people:** Proper medical facilities should be made available to the local communities as they are going through miserable situations due to unavailability of proper road network at most of the places. It is reported that the villagers have to walk down for more than 8 to 10 km to visit a doctor.



(viii) **Extension of veterinary facilities for the livestock population:** The diseases like Foot and Mouth Disease (FMD), etc. are known to spread among the livestock population in the monsoons, to which wild ungulates are highly susceptible. The livestock population should, therefore be regularly checked for such diseases if prevailing and proper veterinary facilities and regular vaccinations should be provided for them in each and every village.

(ix) **Implementation of Eco-development programs:** To achieve success in fulfilling all the above mentioned goals, the implementation of Eco-development programs with the involvement of NGOs is recommended.



## 5. REFERENCES

- Alves J. 1999. Men and tigers in Sariska Tiger Reserve, India. *Cat News* 30: 10-12.
- Angelsen, A. and Kaimowitz, D., 1999. Rethinking the causes of deforestation: Lessons from economic models. *The World Bank Res. Obs.*, 14, 73-98.
- Anon. 1998. Management plan of Sariska Tiger Reserve. Rajasthan. Unpublished report
- Avinandan, D. 2003. Food habits of tiger (*Panthera tigris tigris*) in Sariska Tiger Reserve, Rajasthan. Masters thesis. Saurashtra University. Pp 50.
- Bagchi, S., Goyal, S.P. and Sankar, K. 2003. Prey abundance and prey selection by tigers (*Panthera tigris*) in a semi-arid, dry deciduous forest in western India. *J.Zool. Lond.* 260: 285-290.
- Biswas, S. and Sankar, K. 2002. Prey abundance and food habits of tigers (*Panthera tigris tigris*) in Pench National Park, Madhya Pradesh. *J. Zool. Lond.* 256, 411-420.
- Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. 1993. Distance Sampling: Estimating Abundance of Biological Populations. Chapman and Hall, London. P 446.
- Burnham, K.P., Anderson, D.R. and Laake, J.L. 1980. Estimation of density from line transect sampling of biological populations. *Wildl. Monogr.* 72:202 pp.



Carbone, C. and Gittleman, J. L. 2002. A Common rule for scaling of carnivore density. *Science* 295, 2273-76.

Champion, H.G. and Seth, S.K. 1968. A revised survey of forest types of India. Manager of Publications, Government of India, New Delhi. 404pp.

Chauhan, D.S., Harihar, A., Goyal, S. P., Qureshi, Q., Lal, P. and Mathur, V. B. 2005. Estimating leopard population using camera traps in Sariska Tiger Reserve, Wildlife Institute of India, Dehradun, India, pp 23.

Chundawat, R. S. 2001. Tiger Conservation in dry tropical forests of India. Annual report. Centre for Wildlife Studies. Bangalore. Pp 25.

Cornett, Zane J. 1994. GIS as a catalyst for effective public involvement in ecosystem management decision making. In: *Remote Sensing and GIS in ecosystem management*. Ed. V. Alaric Sample. Island Press. Washington, D.C. 369pp.

Cropper, M. and Griffiths, C., 1994. The interaction of population growth and environmental quality. *Am. Econ. Rev.*, 84, 250-254.

David, A., Qureshi Q., Goyal S. P., Sankar K. and Mathur V. B. 2005. Estimating herbivore abundance using line transect method in Sariska Tiger Reserve. Wildlife Institute of India. Dehradun. India.

Davidar, P., Arjunan, M., Mammen, P.C., Garrigues, J.P., Puyravaud, J.P. and Roessingh, K. 2007. Forest degradation in the Western Ghats biodiversity hotspot: Resource collection, livelihood concerns and sustainability. *Current Science*, 93(11): 1573-1578.

Edgaonkar, A. and Chellam, R. 1998. A preliminary study on the ecology of the leopard (*Panthera pardus fusca*) in the Sanjay Gandhi National



Park, Maharashtra. RR-98/002. 33 pp. Wildlife Institute of India, Dehra Dun.

Edgaonkar, A., Qureshi Q. and Chellam, R 2007. ???

Efford, M. G.; Cowan, P. E. 2004. Long-term population trend of *Trichosurus vulpecula* in the Orongorongo Valley, New Zealand. In: R. L. Goldingay and S. M. Jackson (eds.) The biology of Australian possums and gliders. Surrey Beatty & Sons, Chipping Norton. Pp. 471-483

Ghimire, B.K., Pimbert, M.P 1997. Social change and conservation: an overview of issues and concepts. In: Krishna, P.G., Michel, P.P. (Eds.), Social Change and Conservation. Earthscan Publications Limited, London, pp. 1-45.

Giest, H.J. and Lambin, E.F. 2002. Proximate causes and underlying driving forces of tropical deforestation. *Bioscience*, 52, 143-150.

Godoy, R. et al. 1997. Household determinants of deforestation by Amerindians in Honduras. *World Dev.*, 25, 977-987.

Griffiths, M and Van Schaik, C.P. 1992. The impact of human traffic on the abundance and activity periods of Sumatran Rain forest Wildlife. *Conservation Biology*, Vol. 7 (3): 623-626.

Hames, R.B., 1987. Game conservation or efficient hunting? In the question of the commons. *The culture and ecology of Communal Resources* (eds MacCay, B.J. and Acheson, J.H.), The University of Arizona Press, Tuscon, pp. 92-102.

Hames, R.B., 1991. Wildlife conservation in tribal societies. In *Biodiversity, Culture, Conservation and Ecodevelopment* (eds Oldfield, M.L. and Akom, J.B.), Westview Press, Boulder, pp.172-202.



- Haridas, V.K.; Chandrasekaran, V.A., Kumaraswamy, K. Rajendran, S. and Unnikrishnan, K. 1994. Geomorphological and lineaments studies of Kunjamalai using IRS 1 data with special reference to ground water potentiality. *Trans. Instt. Indian Geographers*. 16 (1): 35-41.
- Jain, R.K. 1998. Remote Sensing Techniques to locate ground water potential zones in upper Urmil river basin, District Chatarpur – Central India. *Journal of the Ind. Soc. of Remote Sensing*. Vol. 26(3) : 135-148.
- Jhala, Y.V. and Qureshi, Q. 2004. Monitoring Tiger Status and Habitat Part-I. A Field Guide. A Technical Publication of Project Tiger Directorate.
- Jodha, N. (1990) *Rural Common Property Resources: Contributions and Crisis*. Foundation day lecture, May 16, 1990, Society for the Promotion of Wasteland Development. Mimeo. New Delhi, India.
- Johari, R. 2003. *Of Sanctions and Sanctuary-Making: The Cultural Politics of Nature in Sariska Tiger Reserve, Rajasthan, India, 1850 – 2000*. MS Thesis. York University.
- Johnsingh, A.J.T., Sankar, K. and Mukherjee, S. 1997. Saving the prime tiger habitat in Sariska Tiger Reserve. *Cat News*. 27-Autumn.
- Johnson, A., 1989. How the Machiguenga manage resources: Conservation or exploitation of nature? *Adv. Econ. Bot.*, 7, 213-222.
- Karanth, K. U. and Sunquist, M. E. 1995. Prey selection by tiger, leopard and dhole in tropical forests. *J. Anim. Ecol.* 64: 439-450.
- Karanth, K. U. and Nichols, J. D. 1998. Estimation of tiger densities using Photographic captures and recaptures. *Ecology* 79 (8): 2852-2862.



- Karanth, U.K. and Sunquist, M.E. 2000: Behavioral correlates of predation by tiger (*Panthera tigris*), leopard (*Panthera pardus*) and dhole (*Cuon alpinus*) in Nagrahole, India.
- Karanth, K. U. and Nichols, J. D. 2000. Ecological status and conservation of tigers in India. Final technical report to the division of International Conservation. US Fish and Wildlife Services. Washington D. C. and Wildlife Conservation Society. New York. Pp124.
- Karanth, K. U. and Nichols, J. D., Kumar, N. S., Link, W. A. and Hines, J. E. 2004a. Tigers and their prey: Predicting carnivore densities from prey abundance. Proceedings of the Natural Academy of Sciences. 101: 4854-4858.
- Karanth, K.U. and Karanth, K.K., 2007. Free to move: conservation and resettlement in the Western Ghats of Karnataka, India, In: Redford, K.H., Fearn, E., (Eds), Protected Areas and Human Displacement: A conservation perspective, working paper 29. Wildlife Conservation Society, New York, pp. 48-59.
- Kawanishi, K. and Sunquist, M. E. 2004. Conservation status of tigers in a primary rainforest of Peninsular Malaysia. Biological Conservation 120: 329-344.
- Khan, J. A, Chellam, R., Rogers, W. A. and Johnsingh, A. J. T. 1995. Ungulate densities and biomass in the tropical dry deciduous forest of Gir, Gujarat, India. J. Trop. Ecol. 12:149-162.
- Kim, K.C. and Weaver, R.D. 1994. *Biodiversity and landscapes*, A paradox of humanity. Cambridge University Press. 431pp.
- Kothari, A., Pande, P., Singh, S.D., Variava, D., 1989. Management of National Parks and Sanctuaries in India: A Status Report. Indian Institute of Public Administration, New Delhi



- Krishnamurthy, J. and Srinivas, G. 1996. Demarcation of geological and geomorphological factors of parts of Dharwar Craton, Karnataka, using IRS LISS II data. *Int. J. Remote Sensing* 17 (16): 3271-3288
- Kruuk, H. 1972. The spotted Hyena. Chicago. The University of Chicago Press.
- Kumar, R, Sahabuddin G, 2005. Effects of biomass extraction on vegetation structure, diversity and composition of forests in Sariska Tiger Reserve, India. *Environmental Conservation* 32 (3): pp 1-12
- Kutty, R. and Kothari, A. 2001. Protected areas in India: A profile. Kalpvriksh Publications, New Delhi.
- Laake, J. L., S. T. Buckland, D.R. Anderson, and K.P. Burnham 1993. *DISTANCE user's guide, Version 2.0*. Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, Colorado, USA.
- Mathur, V.B. 1991. The ecological interaction between habitat composition, habitat quality and abundance of some wild ungulates in India. D.Phil. Thesis. University of Oxford, United Kingdom. 279 Pp.
- Mathur, V.B. and Naithani, S. 1999. Development of Spatial Database of Great Himalayan National Park Conservation Area (GHNPCA) in GIS Domain. Final Report, Wildlife Institute of India, Dehra Dun. 69pp.
- MoEF. 2005: 'Joining the Dots: Report of the Tiger Task Force', Ministry of Environment and Forests.
- Mondal, K. 2006. Leopard and ungulate abundance estimation in Rajaji National Park, Uttranchal. Masters Thesis. Forest Research Institute (Deemed University). Dehradun. Pp 95.



- Mooney, H. A. and Chapin, H. S. 1994. Future directions of global change research in terrestrial ecosystems. *Trends in Ecology and Evolutions*. 9: Pp 371-372.
- Moorie, T.D., Spence, L. E. and Dungenole, C. E. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Hepworth, W.G(ed), Wyoming Game and Fish Department. Wyoming 177pp
- Mukherjee S., Goyal S. P. and Chellam, R. 1994a. Standardization of scats analysis technique for leopard (*Panthera pardus*) in Gir National Park, western India. *Mammalia*, 58: 139-143.
- Nichols J. D. 1992. Capture-recapture models: using marked animals to study populations dynamics. *Bio Science*. 42: 94-102.
- Nagothu, U.S. 2000. Fuelwood and fodder extraction and deforestation: Mainstream views in India discussed on the basis of data from the semi-arid region of Rajasthan. *Geoforum* 32 (2001) 319-332.
- Nagothu, U.S. 2003. Local people's attitudes towards conservation and wildlife tourism around Sariska Tiger Reserve, India *Journal of Environmental Management* 69 (2003) 339-347.
- Negi, Y.S. and Bhalla, P., 2002. Collection and marketing of important medicinal and aromatic plants in tribal areas of Himachal Pradesh. *Indian Forester*, 5, 641-647.
- Olson, S. 1998. Indigenous use of non-timber forest products by the Guidar of Northern Cameroon. Poster abstract presented at the North American Conference on Enterprise Development through Agroforestry: Farming the Agroforest for Speciality Products (Minneapolis MN).



- Otis, D. L., Burnham K. P., White G. C. and Anderson D. R. 1978. Statistical interference from capture data on closed animal populations. *Wildlife Monogram*. 62. Pp 135.
- Pascoe, E. H. 1950. A manual of the geology of India and Burma. 3 vols. Govt. of India press. Nasik.
- Parmar, P.J.1985. A contribution of the flora of Sariska Tiger Reserve, Alwar District, Rajasthan. *Botanical Survey of India*, Vol: 27, Nos. 1-4: pp. 29 – 40.
- Pienaar, U.De V. 1969. Predator prey relationships amongst the larger mammals of the Kruger National Park. *Koedoe* 28: 93-165.
- Porter, G., Clemencon, R., Ofosu-Amaah, W., Philips, M., 1998. Study of GEFs overall performance. World Bank, Washington, DC.
- Pradeep Raj, Nand Lal, and Soni, G.K. 1996. Nature of aquifer in parts of granite terrain in Mahboobnagar, District A.P. *Geo. Soc. India*. 48(3): 299-307.
- Ranganjan, M. and Shahabuddin, G., 2006. Displacement and relocation from protected areas: Towards a biological and historical synthesis. *Conservation and Society* 4, 359-378.
- Rao, D.P., Bhattacharya, A. and Reddy P.R. 1996. Use of IRS- IC data for geological and geomorphological studies. *Current science* 70(7): 619-623.
- Rexstad, E. A., and Burnham, K. P. 1991. User's guide for interactive program CAPTURE. Colorado Cooperative Wildlife Research Unit, Colorado State University, Fort Collins Co. 29pp.
- Robbins, P. (1994). Goats and grasses in Western Rajasthan: Interpreting change. A collection of papers from Gujarat and Rajasthan.



Rodgers, W. A. and Panwar, H. S. 1988. Planning a Wildlife Protected Area Network in India. Vol I & II. Wildlife Institute of India, Dehra Dun.

Rodgers, W.A. 1990. A preliminary ecological survey of Algal Spring, Sariska Tiger Reserve, Rajasthan. *Journal of the Bombay Natural History Society* 87(2): 201-209.

Rodgers, W. A. 1991. A preliminary ecological survey of Algal spring, Sariska Tiger Reserve, Rajasthan. *J. Bombay Nat. Hist. Soc.* 7: 201-209.

Roughgarden, J., Running, S.W. and Matson, P.A. 1991. What does remote sensing do for ecology? *Ecology*. 72:1918-1922.

Rudnai, J. A. 1974. The pattern of lion predation in Nairobi Park. *E. Afr. Wildl.J.* 12:213-225.

Shahabuddin, G, Kumar R, Shrivastava M., 2005. Pushed over the edge – village relocation from Sariska. *Economic and Political weekly*. Pp 3563-3565.

Shahabuddin, G, Kumar R, Shrivastava M., 2005. 'Forgotten Villages: A People's Perspective on Village Displacement from Sariska Tiger Reserve', Technical Report, Council for Social Development and National Foundation for India.

Sample, V. Alaric 1994a. Remote sensing and GIS in ecosystem management. Ed. V. Alaric Sample. Island Press. Washington, D.C. 369pp.

Sample, V. Alaric 1994b. Realizing the potential of remote sensing and GIS in ecosystem management planing, analysis and policy making. *In. Remote sensing and GIS in ecosystem management*. Ed. V. Alaric Sample. Island Press. Washington, D.C. 369pp.



- Sankar, 1994. Ecology of three large sympatric herbivores (chital, sambar, nilgai) with special reference to the reserve management in Sariska Tiger Reserve, Rajasthan. Ph.D., Thesis. University of Rajasthan. Jaipur, India.
- Sankar, K., and Johnsingh, A.J.T. 2002. Food habits of tiger (*Panthera tigris*) and leopard (*Panthera pardus*) in Sariska Tiger Reserve, Rajasthan, India, as shown by scat analysis. *Mammalia*: 66(2): 285-289.
- Sankar, K., Goyal, S. P. and Qureshi Q. 2005. Assessment of status of tiger (*Panthera tigris*) in Sariska Tiger Reserve. A report submitted to the Project Tiger Directorate. Wildlife Institute of India, Dehradun. Pp- 39.
- Schaller, G.B. 1972. The Serengeti lion. University of Chicago press. Chicago.
- Seidensticker, J.C. 1976. On the ecological separation between tigers and leopards. *Biotropica* 8:225-34.
- Seidensticker, J.C, Sunquist, M.E. and McDougal, C.W. 1990. Leopards living at the edge of Royal Chitawan National Park, Nepal. In: J.C. Daniel and J.S. Seraro (Eds.), Conservation in developing countries: problems and prospects, pp. 415-23. Bombay Natural History Society, Bombay, India: Oxford University Press.
- Sharma, A., 2003. Displacement from wildlife protected areas: Implications for conservation and livelihoods. The case of Kuno Wildlife Sanctuary, Madhya Pradesh. *Social Change* 33, 89-114.
- Shahabuddin, G. and A. Shah. 2003. Relocation of people from wildlife areas: Socio-economic and ecological issues. *Economic and Political Weekly*, 38(47): 4945-4946.
- Singhal, R.M., Kumar, S. and Jeeva, V., 2003. Forest and forestry research in India. *Trop. Ecology*, 44, 55-61.



- Smith, J.L.D., McDougal, C.W. and Miquelle, D. 1989. Scent marking in free-ranging tigers, *Panthera tigris*. *Anim. Behav.* 37: 1-10.
- Soule, M E and Terborgh, J. 1999. *Continental Conservation*, Island Press, Washington DC and Covelo, California.
- Sunquist, M.E. 1981. The social organisation of tigers (*Panthera tigris*) in Royal Chitwan National Park, Nepal. *Smithsonian contribution to Zoology # 336*. Smithsonian Institution Press, Washington. 98pp.
- Stearman, A.M. and Redford, K.H., 1992. Commercial hunting by subsistence hunters: Siriono Indians and Paraguayan Caiman in lowland Bolivia. *Human Org.*, 71,, 235-244.
- Tiger Task Force. 2005. *Joining the dots*. Union Ministry of Environment and Forests (Project Tiger).
- Tripathi, J.K., Panigrahi, R.C. and Kumar, K.V. 1996. Geological and geomorphological studies of the part of Ganjan district, Orissa by remote sensing techniques. *Journal of the Indian Society of Remote Sensing* 24(3): 170-177.
- Nagothu, U.S. 2000. Fuelwood and fodder extraction and deforestation: Mainstream views in India discussed on the basis of data from the semi-arid region of Rajasthan. *Geoforum* 32 (2001) 319-332.
- Nagothu, U.S. 2003. Local people's attitudes towards conservation and wildlife tourism around Sariska Tiger Reserve, India *Journal of Environmental Management* 69 (2003) 339-347.
- Varman, K. S. and Sukumar, R. 1995. The line transect method for estimating densities of large mammals in a tropical deciduous forest: An evaluation of models and field experiment. *J. Bioscience.* 20:273-287.



---

Wilson, D. S. 1975. The adequacy of body size as a niche difference. *Am. Nat.*  
109: 769-784.

Western, D. and Wright R.M. (eds), 1994. *Natural Connections: Perspectives  
in Community-based Conservation*. Washington (DC): Island Press

## Annexure - I

# Annexure - I

ASSESSMENT OF STATUS OF TIGER (*Panthera tigris*)  
IN  
SARISKA TIGER RESERVE, RAJASTHAN



भारतीय वन्यजीव संस्थान  
Wildlife Institute of India

2005

ASSESSMENT OF STATUS OF TIGER (*Panthera tigris*) IN  
SARISKA TIGER RESERVE, RAJASTHAN

ASSESSMENT OF STATUS OF TIGER (*Panthera tigris*)  
IN  
SARISKA TIGER RESERVE, RAJASTHAN

A REPORT



भारतीय वन्यजीव संस्थान  
Wildlife Institute of India

2005

ASSESSMENT OF STATUS OF TIGER (*Panthera tigris*)

IN

SARISKA TIGER RESERVE, RAJASTHAN

A REPORT

---

**Citation:**

Sankar, K., S.P. Goyal and Qamar Qureshi. 2005. Assessment of status of tiger (*Panthera tigris*) in Sariska Tiger Reserve, Rajasthan. A Report submitted to the Project Tiger, Ministry of Environment & Forests, Govt. of India, New Delhi. Wildlife Institute of India, Dehra Dun. 41 Pp.

# ASSESSMENT OF STATUS OF TIGER (*Panthera tigris*) IN SARISKA TIGER RESERVE, RAJASTHAN

## THE TEAM

- Investigators** :
- 1) Dr.K.Sankar, Senior Reader,
  - 2) Dr. S.P. Goyal, Senior Reader,
  - 3) Sh. Qamar Qureshi, Reader
- Advisors** :
- 1) Sh. P.R. Sinha, Director,
  - 2) Dr. A.J.T. Johnsingh, Dean,  
Faculty of Wildlife Sciences
  - 3) Dr.Y.V.Jhala, Senior Reader,
  - 4) Dr. V.B. Mathur, Professor,
- Researchers** :
- Mr. Bhaskar Acharya, Mr. Bibek Yumnam,  
Dr. Praveen Garhwal, Mr. Vijayakumar,  
Mr. K. Rajapandian, Mr. Jeewan Singh Jalal,  
Mr. Chitaranjan Dave and Mr. Kartikeya S.  
Chauhan
- Technical inputs** :
- Mr. Panna Lal and Mr. Vinod Thakur

# Contents

---

	Pages
<i>Acknowledgements</i>	<i>i</i>
1. Introduction	1
2. Literature Survey	1
3. Study Area	2
3.1 Location	2
3.2 Prey Species	2
4. Objective	6
5. Duration and Period of Study	6
6. Methods	6
7. Results and Discussion	8
8. Findings and Recommendations	21
9. Scope of Future Work	23
10. References	24
Appendix 1	28
Appendix 2	34
Appendix 3	37

\*\*\*\*\*

## **Acknowledgements**

The Director, Project Tiger, Ministry of Environment and Forests, Government of India, New Delhi, is thanked for the funding support for this study. The Chief Wildlife Warden, Rajasthan, Sh. S.K. Jain, Field Director, Sh. Priyaranjan, Deputy Director, and the staff of Sariska Tiger Reserve extended utmost cooperation during the field studies at Sariska. They all deserve special thanks.

The study would not have been possible without the support from Mr. Naveen Chand Kandpal, Mr. Vinod Bist, Mr. Udai Singh Rawat, Mr. Jai Prakash and Kripal Singh, Wildlife Institute of India (WII) and Mr. Ram Karan alias Chottu. Mr. Gyanesh Chhibber typed the manuscript and Mr. Virendra Sharma did the DTP of the same. We are thankful to all of them.

## 1. INTRODUCTION

Tigers are found in diverse habitat types including dry deciduous, moist deciduous, semi-evergreen, wet evergreen, riverine, swamp and mangrove forests. They show remarkable tolerance to variations in altitudes, temperature and rainfall regimes (Sunquist, 1981; Karanth, 1993). It is the largest obligate terrestrial carnivore in any of the mammalian assemblages in which it occurs preying on the larger ungulates living in those assemblages (Seidensticker, 1976). Wickramanayake *et al.*, (1999) classified Sariska Tiger Reserve as Tiger Conservation Unit – III (TCU 3) among the dry deciduous habitat types. Tiger is territorial, but the size of the territory is the function of density and biomass of large prey species in its habitat (Sunquist, 1981; Karanth, 1991; Karanth *et al.* 2004). This makes the species vulnerable to local extinctions due to changes in the habitat and depletion of prey base due to poaching (Karanth, 1991; Griffiths and Van Schaik, 1992). Degraded habitats and depleted prey base may cause the species to depend more or solely on the domestic livestock available in and around the area giving way to the problem of human-animal conflict usually leading to the death of the tiger (Gogate and Chundawat, 1997).

## 2. LITERATURE SURVEY

Tiger has been studied in its distribution range with respect to its general ecology, home range, habitat use, prey selection, conflicts with local people (Seidensticker *et al.* 1999). Different aspects of tiger conservation studied in Indian subcontinent are on general ecology (Schaller, 1967; Johnsingh, 1983), social organization (Sunquist, 1981), land tenure system (Panwar, 1979; Smith *et al.* 1987; Gogate and Chundawat, 1997; Vanak 1997), dispersal and communication (Smith, 1984), its effect on prey species (Tamang, 1983; Karanth, 1993), prey selection (Karanth and Sunquist, 1995; Biswas and Sankar, 2002; Bagchi *et al.* 2003), food habits (Schaller, 1967; Johnsingh, 1983; Johnsingh *et al.* 1993; Sankar, 1994; Stoen, 1994; Sankar and Johnsingh, 2002), and tiger - leopard interaction (Seidensticker, 1976). Besides these, lots of natural history accounts and some short term studies are also available *eg.* Corbett (1944), Mc Dougal (1977), Sankhala (1977), Singh (1984), Thapar, (1986, 1989). The above mentioned studies give an overview of tiger ecology from only some of the habitats where it occurs. Tiger population in dry deciduous forests needs focused and sustained conservation efforts as these forests have large expanse, high resource dependency of people and low tiger densities (Gogate and Chundawat, 1997).

Only a few studies have been conducted in Sariska on tigers and their prey base. Mathur (1991) studied ungulate – habitat interaction, Sankar (1994) studied prey abundance and food habits of tigers, Sankar and Johnsingh (2002) studied food habits of

tiger and leopard and Avinandan (2003) studied prey selection by tigers in Sariska. Avinandan (2003) estimated population of tigers in Sariska-Kalighati-Pandupole valley (ca. 45 km<sup>2</sup>) to be 5 to 7 individuals. The reported tiger population in the entire Tiger Reserve was 26 individuals during 2003 (Anon, 2003).

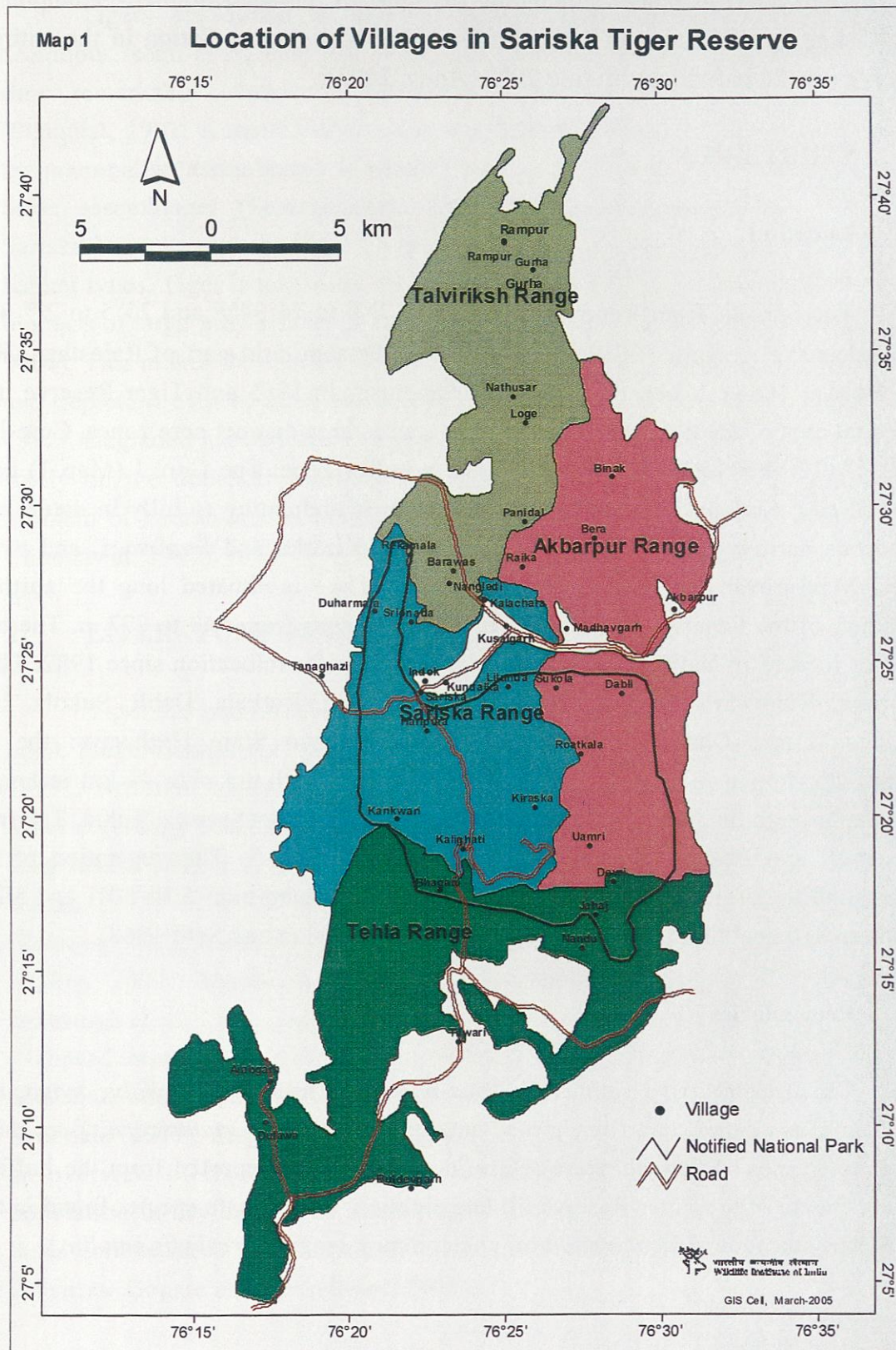
### 3. STUDY AREA

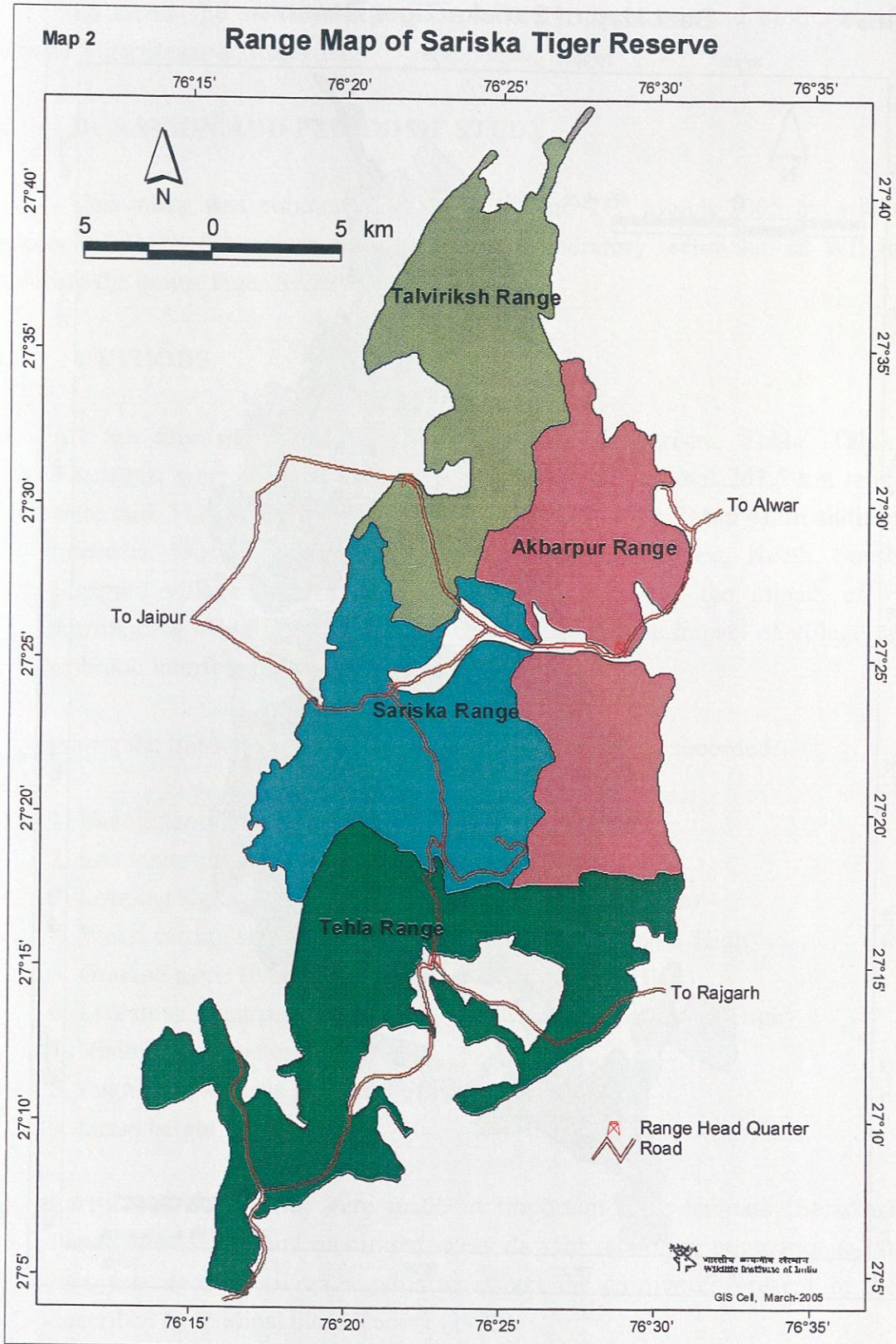
#### 3.1 Location

The Sariska Tiger Reserve (STR), (74°17' E to 76°34'E and 25°5 to 27° 33 N) is situated in the Aravalli Hill Range and lies in the semi-arid part of Rajasthan (Rodgers and Panwar 1988). It became a Wildlife Sanctuary in 1955 and Tiger Reserve in 1982. The total area of the tiger reserve is 881 km<sup>2</sup>, with three distinct core zones, Core-I (273.8 km<sup>2</sup>), II (126 km<sup>2</sup>) and III (97.5 km<sup>2</sup>) and a buffer zone. The Core I (Map 1) has been notified as a National Park in 1982. The terrain is undulating to hilly in nature and has numerous narrow valleys, two large plateaus - Kiraska and Kankwari, and two large lakes, Mansarovar and Somasagar. The Silisad Lake is situated long the northeastern boundary of the Reserve. The altitude of Sariska ranges from 540 to 777 m. There are 12 villages located in National Park area, which are due for relocation since 1982. They are: Haripura, Kankwari, Bhagani, Devri, Umri, Kiraska, Rotkala, Dabli, Sukola, Lilunda, Rekhamala and Dhuarmala (Map 1). There are two State Highways: the Alwar-Thanagazhi-Jaipur and the Sariska-Kalighati-Tehla, which are over 44 km in length and traverse through the heart of the National Park. The Ranges (Sariska, Tehla, Talvirish and Akbarpur) and Beats of Sariska are given in Map 2 & 3. The vegetation of Sariska correspond to northern tropical dry deciduous forests (subgroups 5 B: 5/E1 and 5/E2) and Northern Tropical thorn forest (sub group 6 B) (Champion and Seth 1968).

#### 3.2 Prey species

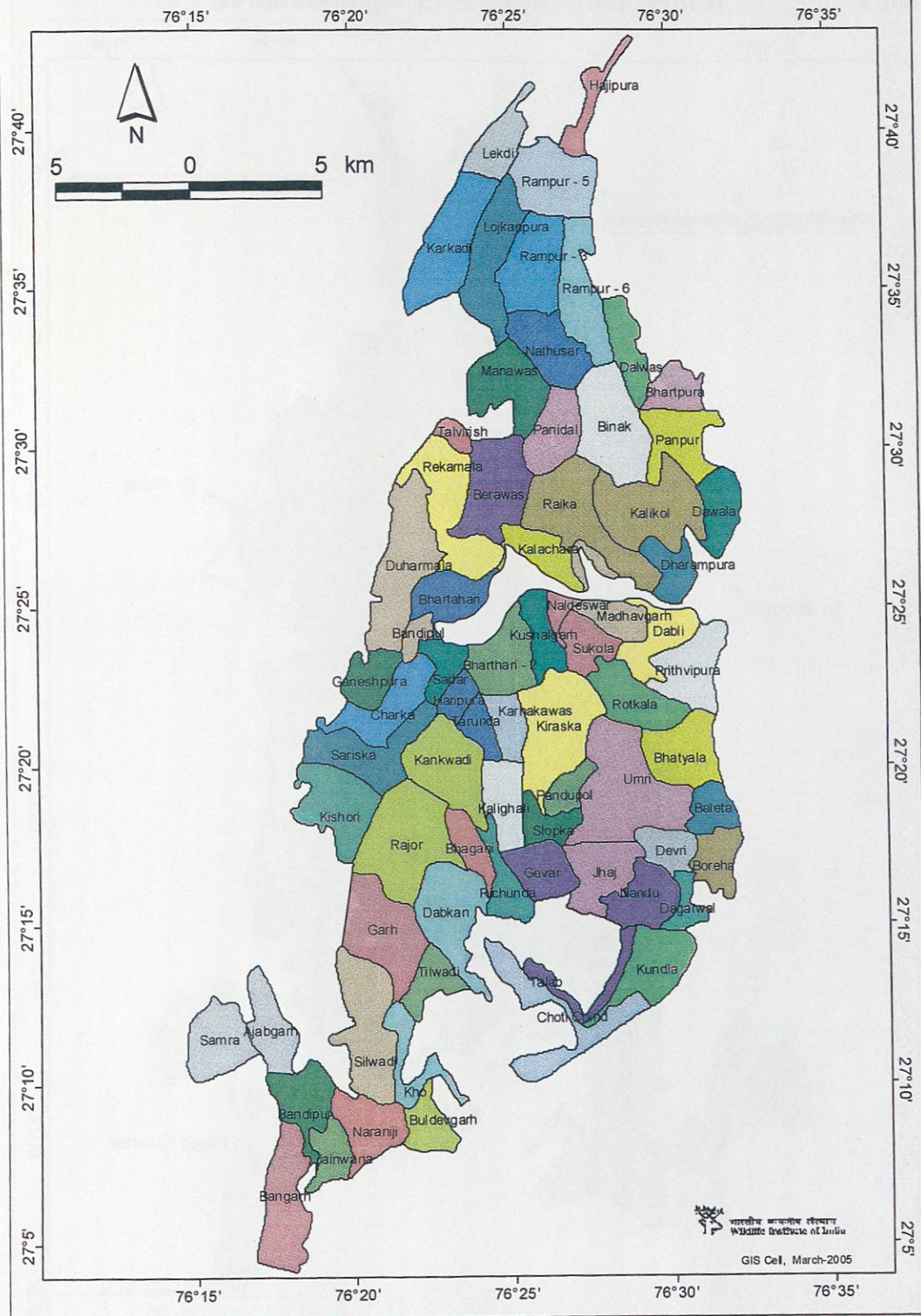
Chital (*Axis axis*), sambar (*Cervus unicolor*), nilgai (*Bosephalus tragocamelus*), wild pig (*Sus scrofa*), and four horned antelope (*Tetracerus quadricornis*) are the major ungulate species. A few chinkara (*Gazella gazella*) were reported from the buffer areas around Baleta of the Tiger Reserve till late eighties. The primate species found in the area are rhesus macaque (*Macaca mulatta*) and common langur (*Presbytis entellus*).





Map 3

### Beat Map of Sariska Tiger Reserve



#### 4. OBJECTIVE OF THE STUDY

To assess the status of tiger, co-predators, prey base and biotic interference in Sariska Tiger Reserve, Rajasthan.

#### 5. DURATION AND PERIOD OF STUDY

This study was conducted between 3<sup>rd</sup> and 11<sup>th</sup> March 2005 by a team of two faculty members, 8 research fellows and one laboratory technician of WII in Sariska, covering the entire Tiger Reserve.

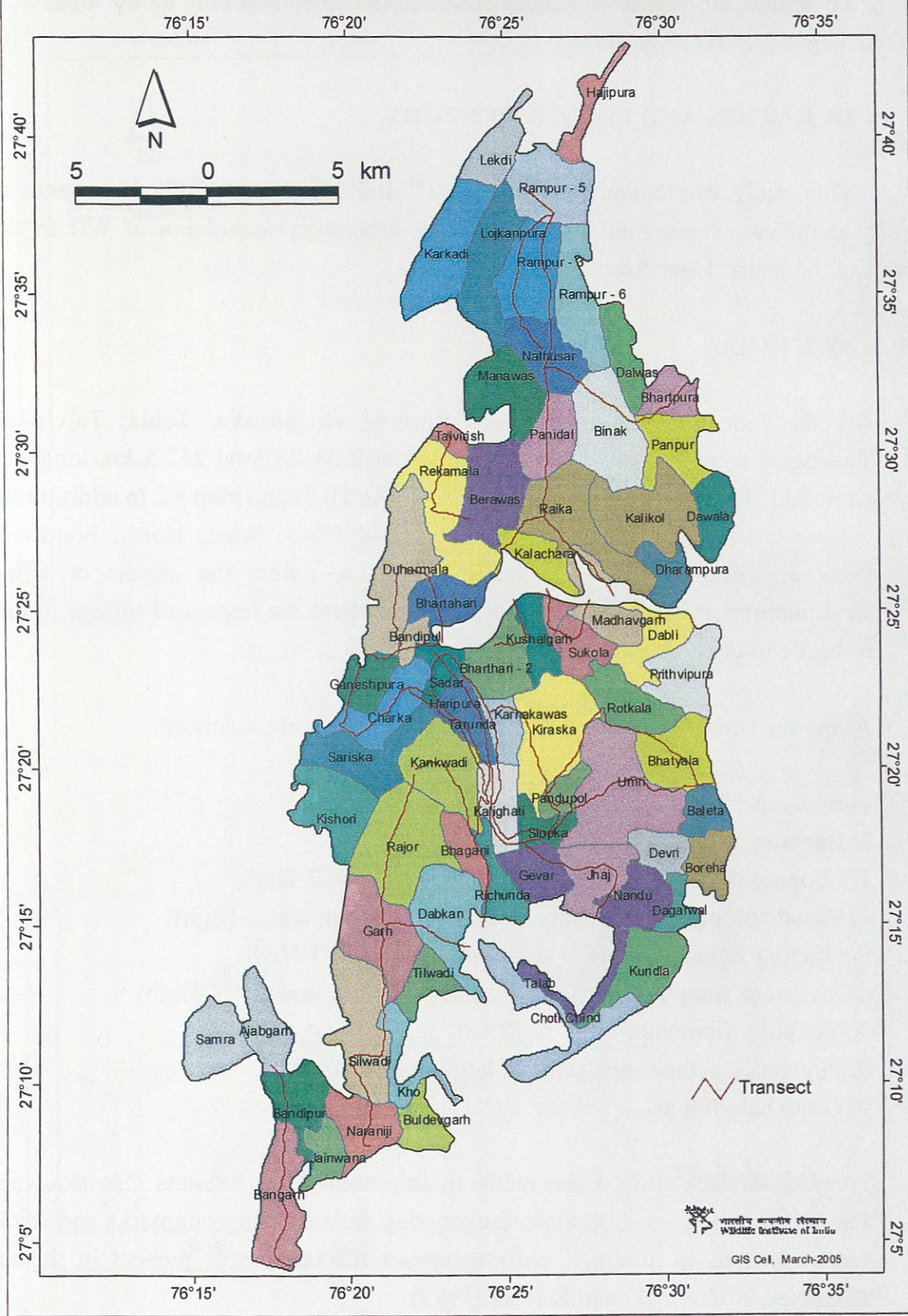
#### 6. METHODS


- a) All the four ranges of the Tiger Reserve viz Sariska, Tehla, Talviriksh and Thanagazi were covered by foot/vehicle transects. In total 267.5 km long transects were laid. The transect length varied from 2 to 20.5 km (Map 4). In addition to these transects, four line transects were also laid (East, West, North, South) around Haripura village located in National Park, to assess the impact of village on surrounding habitat conditions till the point where the impact of village in the form of biotic interference started decreasing.

Along the transects at every 500 m, the following were recorded:

1. Encounter rate of wild animals
  2. Encounter rate of livestock
  3. Lopping signs (0-None, 1-Low, 2-Medium and 3-High)
  4. Wood cutting signs (0-None, 1-Low, 2-Medium and 3-High)
  5. Grazing signs (0-None, 1-Low, 2-Medium and 3-High)
  6. Livestock dung/pellets (0-None, 1-Low, 2-Medium and 3-High)
  7. Visibility (in meters)
  8. Pugmarks, scrapes and scats of large carnivores
  9. Grass height (cm).
- b) Forty four track plots were made in important tiger habitats (Sariska-Kalighati-Pandupole valley) and monitored every day for recording pugmarks and tracks. Cat lure was used in all track plots to attract the carnivores present in the area, as described by Zielinski and Kucera (1995).
- c) Camera Trap was used in selected areas along with the track plots to identify and ascertain the identity of individual large carnivores.

Map 4 **Transect Locations in Sariska Tiger Reserve**




 भारतीय वन्यजीव संस्थान  
 Wildlife Institute of India  
 GIS Cell, March-2005

## 7. RESULTS AND DISCUSSION

We did not come across any evidence of tiger (direct sighting, indirect evidences such as pugmarks, scats and scrape marks) during the field visit. In total, we encountered 13 individual tracks and fifteen scats (fresh and old) of leopard (*Panthera pardus*) along the transects. The location of the leopard pugmarks and scats are shown in the Map 5.

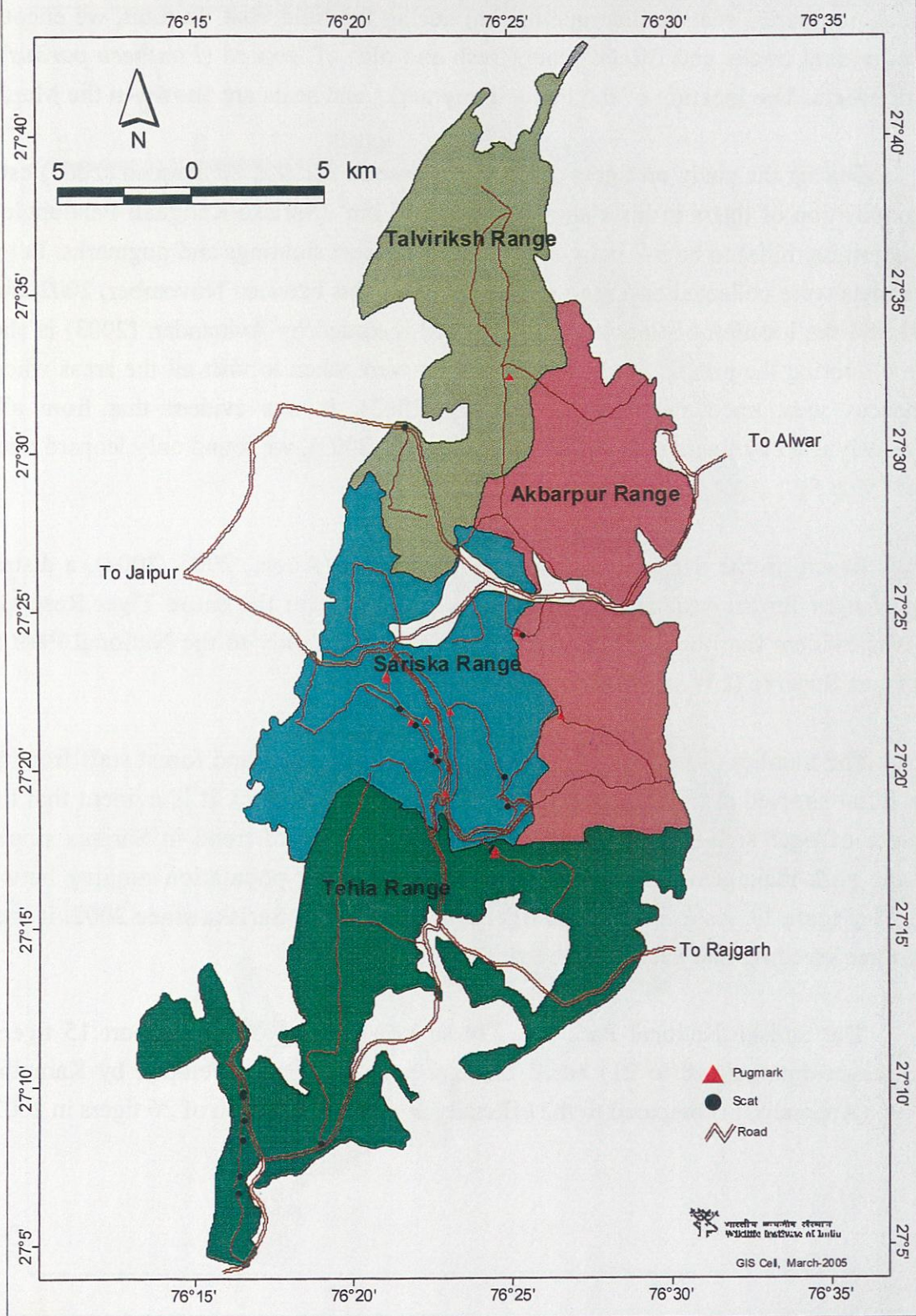
During the study on tigers and its prey base in Sariska, Avinandan (2003) estimated the population of tigers in his study area of ca. 45 km<sup>2</sup> (Sariska-Kalighati-Pandupole valley and adjoining hills) to be 5-7 individuals based on direct sightings and pugmarks. In total, 77 tiger scats were collected and analysed for prey remains between November, 2002 and May, 2003 and the location of tiger evidences (scats) recorded by Avinandan (2003) is shown in Map 6. During the present study, special efforts were taken to visit all the areas where tiger evidences were encountered by Avinandan (2003). It was evident that from all areas previously used by tigers in 2002-2003 (Avinandan, 2003), we found only leopard tracks and signs (Map 5).

Based on the available secondary information (Anon., 2003, 2004), a distribution map of tiger for the year 2003 and 2004 was prepared for the entire Tiger Reserve (Map 7). It is evident that the tiger distribution was confined only to the National Park area of the Tiger Reserve (274 sq km).

The number of tiger sightings reported by the tourists and forest staff from 1997 to July 2004 showed a declining trend since 1999 (Figure 1 & 2). It is evident that the total number of tiger sightings observed to be on the downward trend in Sariska since 1999, but the park management consistently reported the tiger population ranging between 24 and 27 (Figure 1). As there were no tiger cubs reported in Sariska since 2002, it is evident that tiger breeding had been affected since 2002.

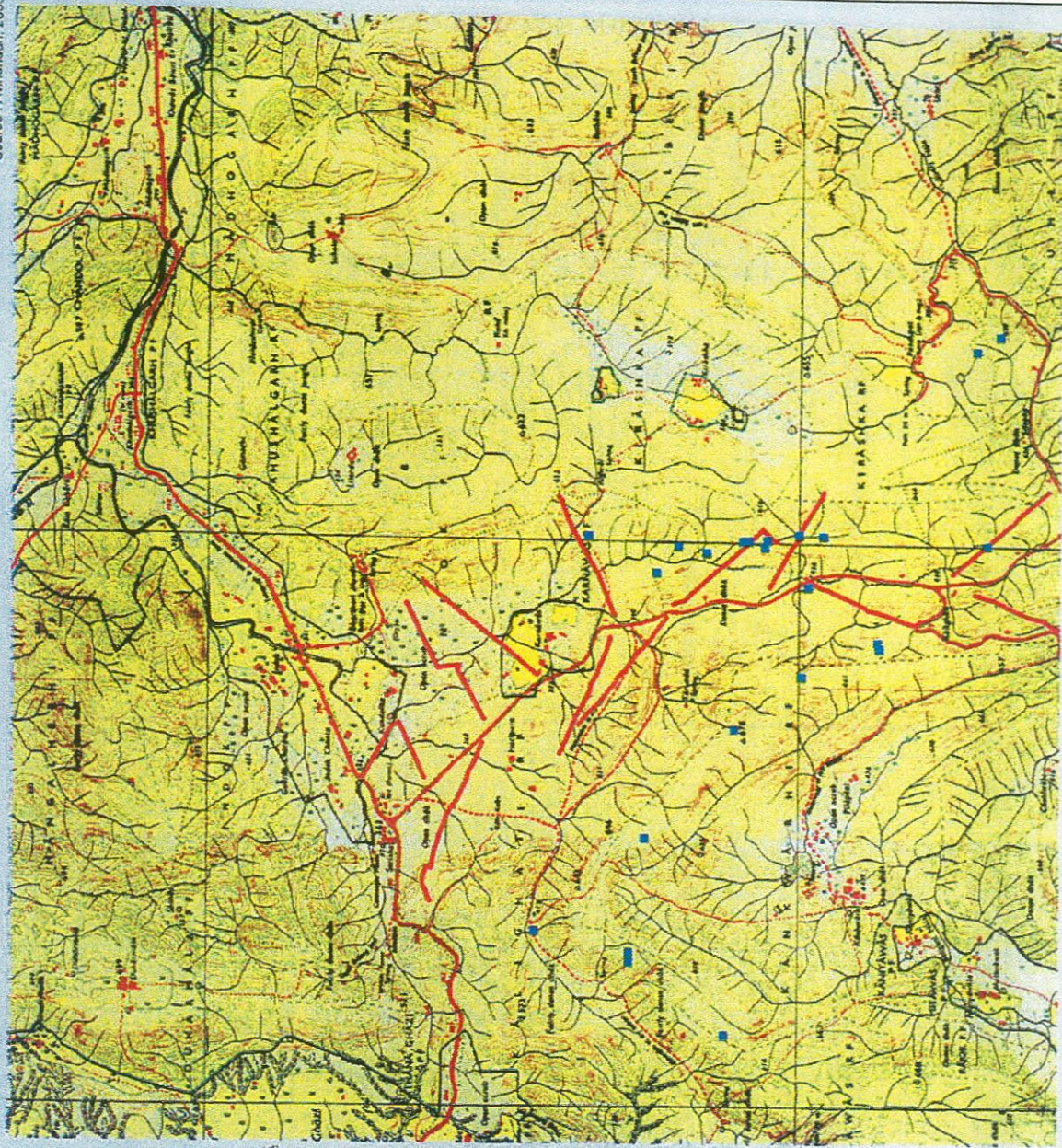
The Sariska National Park (ca. 274 sq km) could possibly support 15 tigers (95% Confidence Interval: 10 to 21) based on tiger-prey equation developed by Karanth *et. al.* (2004) (Appendix 1) compared to the officially reported population of 26 tigers in 2003.

Map 5 Leopard signs recorded in Sariska Tiger Reserve

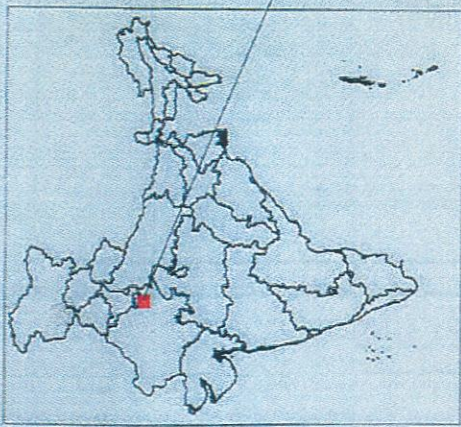


**Study Area (Sariska Tiger Reserve) Showing Transect and Scat Locations**

Source : Avinandan, 2003



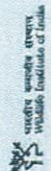
**Map 6**



1 0 1 Kilometers



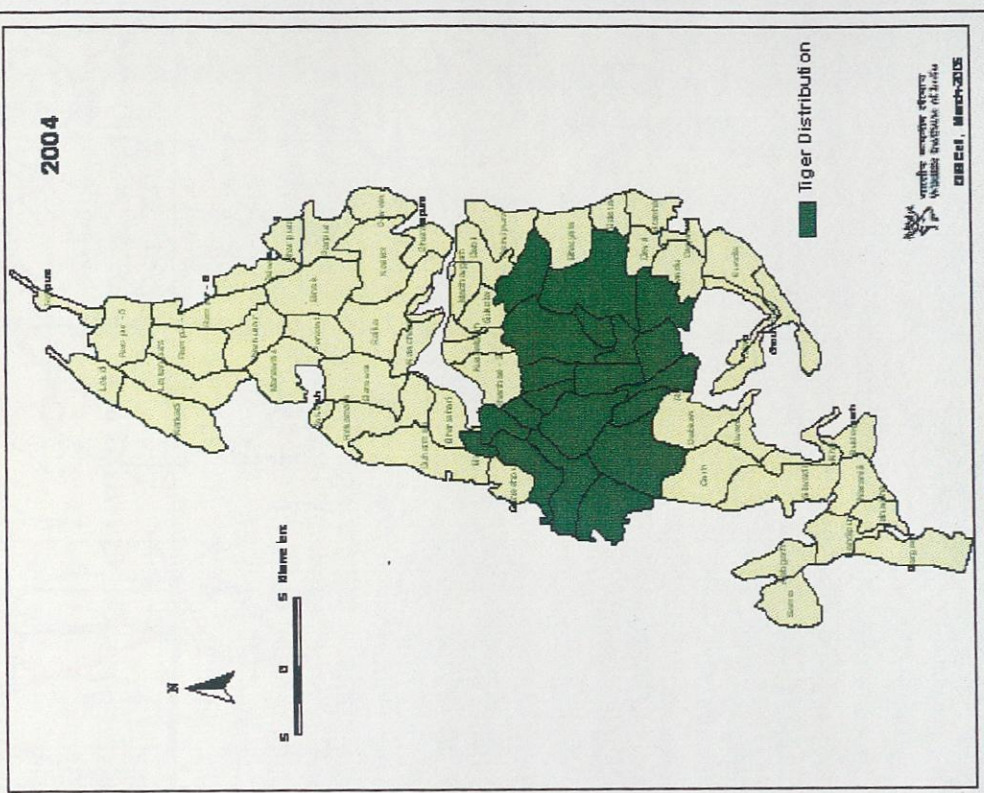
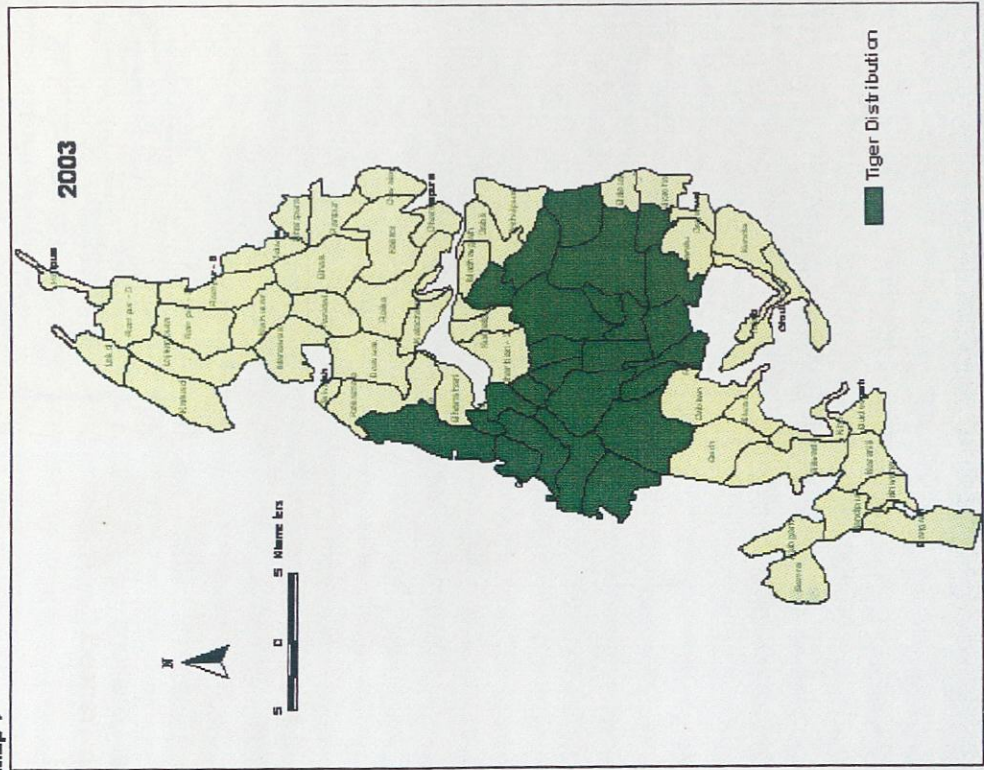
■ Scat Locations  
 Line Transect



WILDLIFE INSTITUTE OF INDIA  
 PUNJAB UNIVERSITY CAMPUS  
 DEWAS, RAJASTHAN

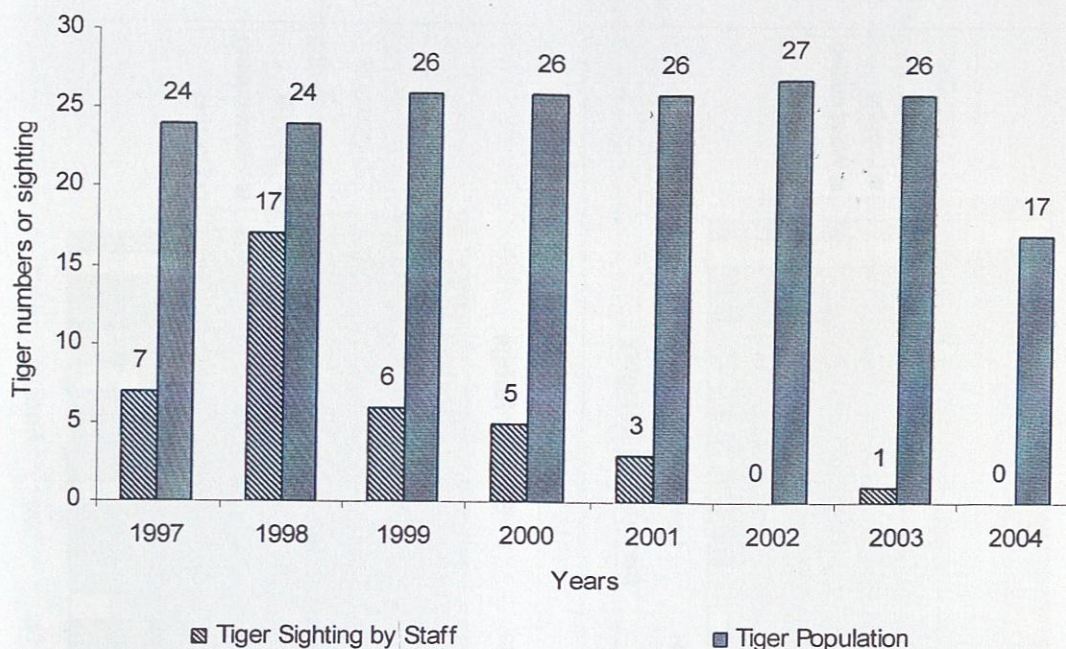
GIS Cell, 2003

**Map 7 Tiger Distribution in Sariska Tiger Reserve based on Pugmark evidences**



**Wildlife Institute of India**
  
 2013/14

Figure 1: Tiger population and tiger sightings in Sariska from January 1997 to July 2004



(Source: Anon., 2003 & 2004, Forest Department, Sariska Tiger Reserve).

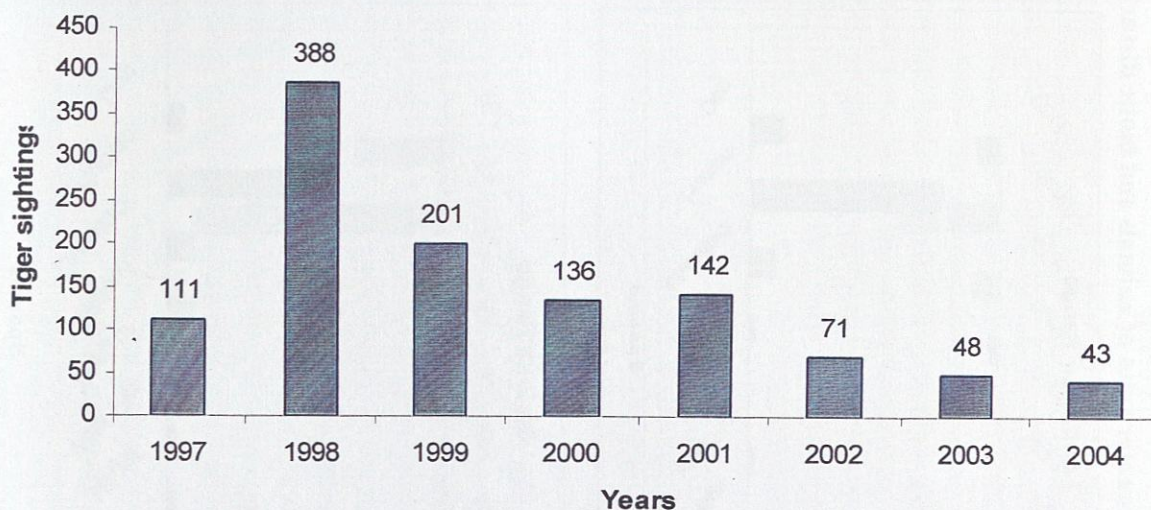


Figure 2. Number of tiger sightings by tourists in Sariska from 1997 to 2004.

Except in Sariska Range, the encounter rate observed for wild prey species of tigers (chital, sambar, nilgai, langur, wild pig) in other Ranges (Akbarpur, Tehla and Talviriksh) was very low (Figure 3 & 4). The encounter rate of domestic livestock observed was very high in all the four Ranges within Sariska Tiger Reserve as compared to the wild prey encounter. The density of wild ungulates in different Ranges of Sariska recorded between

Figure -3. Encounter rates of animals and biotic disturbances in Sariska Tiger Reserve (Akbarpur and Sariska Ranges.)

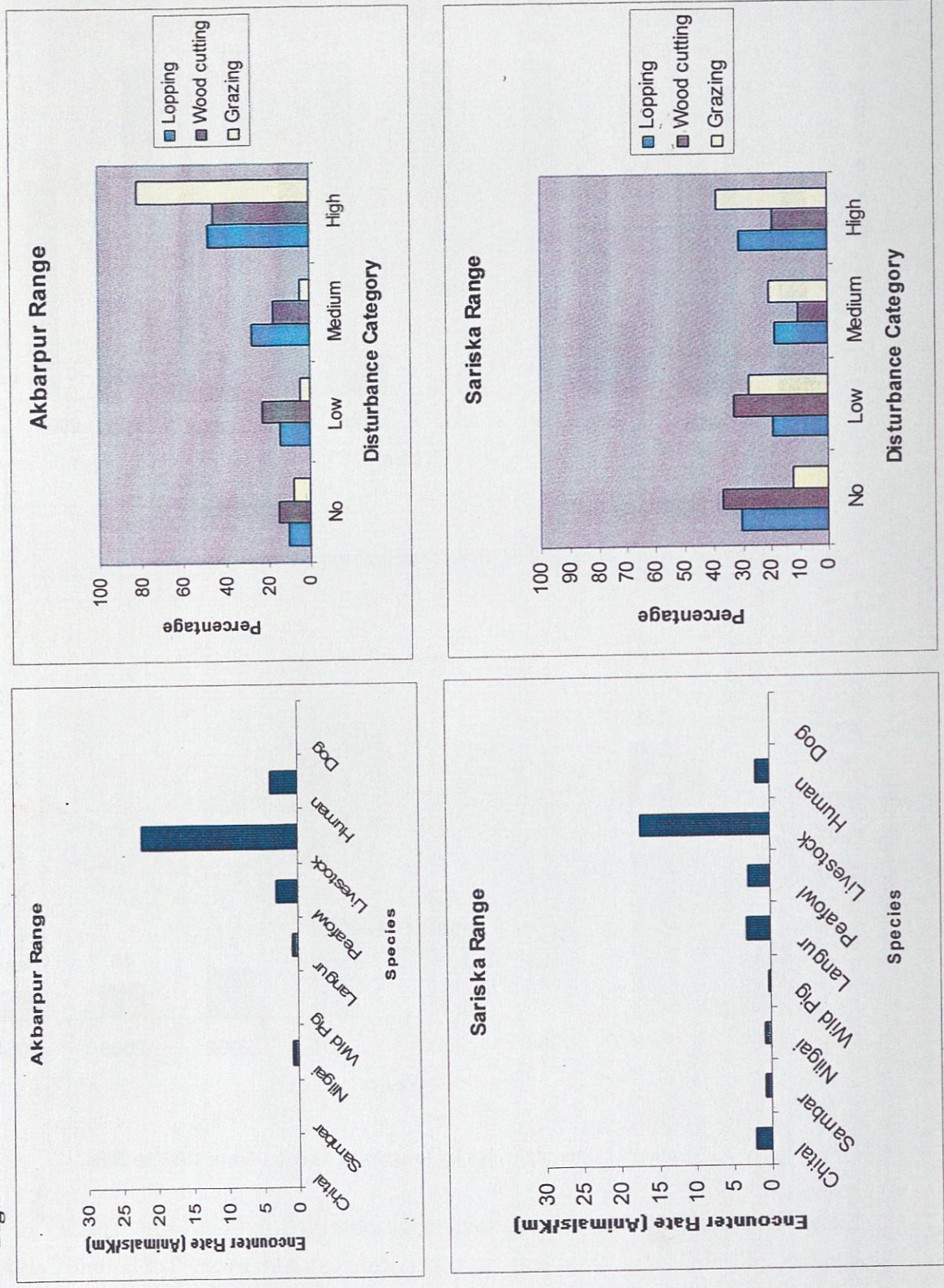
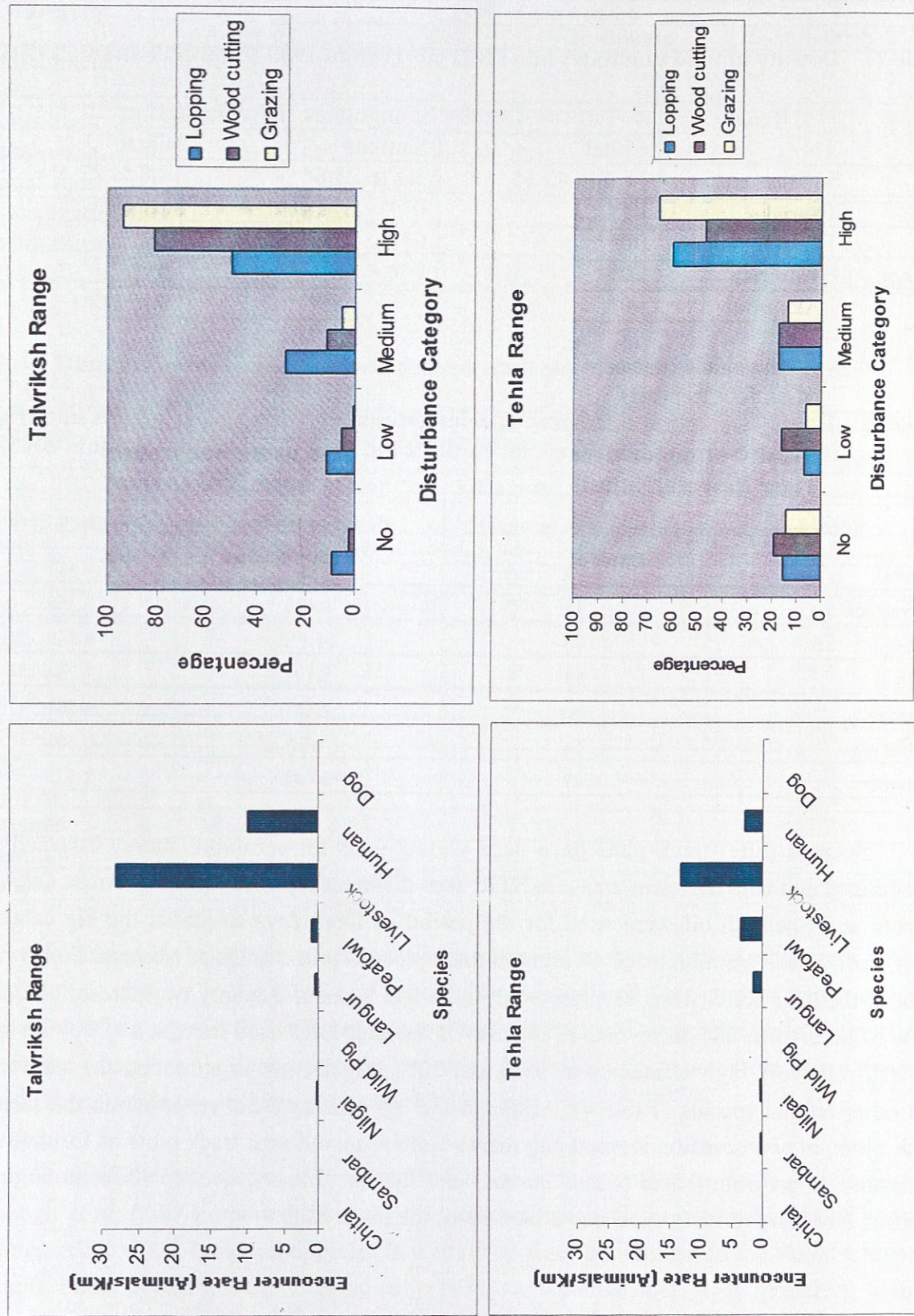


Figure -4. Encounter rates of animals and biotic disturbances in Sariska Tiger Reserve (Talvriksh and Tehla Ranges).



1988 and 1989 is given in Table 1. The density of major prey species observed in the prime tiger area (Sariska Range) is given in Table 2 (Avinandan, 2003). The trend observed with regard to the relative abundance of wild ungulates in different Ranges of Sariska Tiger Reserve was very similar between 1988-89 and 2005 (the present study).

**Table 1. Density of wild ungulates in STR from 1988 to 1989 (Source: Sankar, 1994).**

S.No.	Range	Density of ungulates, individuals / km <sup>2</sup>		
		Chital	Sambar	Nilgai
1	Sariska	15.1 to 43.1*	5.1 to 25.6*	10.8 to 27.3*
2	Tehla	0**	0**	1.1 to 1.8**
3	Talvirish	0**	0**	0**
4	Akbarpur	0*	0 to 4.85*	0 to 10.1*

\* Based on vehicle transects

\*\* Based on foot transects

**Table 2. Density of major tiger prey species estimated using line transects in Sariska Tiger Reserve, Rajasthan, November 2002 to April 2003 (Avinandan, 2003)**

Species	Sample Size (groups)	Density= No./km <sup>2</sup>	Standard Error
Chital	99	27.622	7.637
Livestock	45	6.472	3.356
Langur	40	14.132	4.868
Nilgai	63	5.191	1.264
Peafowl	181	20.81	6.461
Wild pig	14	1.64	0.607
Sambar	57	8.442	2.531

Scented (lure) track plots have been widely used for carnivore survey especially in low density and data deficient areas. In STR, four different types of lures *viz.* Anise Oil, Cat, Coyote and Shellfish oil were used for the period of three days to attract the big cats and other carnivores. We monitored 44 scented track plots in prime areas of National Park where most of the tiger activity has been reported in the last 5 years. Seventy two percent plots had signs of herbivores and carnivores (Table 3). Of the four lures used the Cat and Coyote lures showed relatively high efficiency of 95% and 70% respectively in attracting the carnivores and other animal species (Table 4). Although the big cats were not recorded on the scented track plots, in two occasion leopard pug marks were observed near track plots in Tarunda and Kalighati. Apart from jackal (*Canis aureus*) and hyaena (*Hyaena hyaena*), several ungulate species, birds and rodents were also observed on the track plots.

**Table 3. Presence of animals observed on scented track plots (n=44) in Sariska Tiger Reserve.**

Category	Type of Lure used			
	Anise oil	Cat	Coyote	Shellfish
Total number of plots	2	21	20	1
Number of plots having animal signs	1	20	14	1
Per cent plots having animal signs	50	95	70	100

**Table 4. Observed animal signs (n=92) on scented track plots in Sariska Tiger Reserve.**

Species	Type of Lure used				Per cent of total signs
	Anise oil	Cat	Coyote	Shellfish	
Bird	1	4	1		6.5
Cattle	1	6	4		12.0
Chital		7	2	1	10.9
Dog		1	2		3.3
Goat	1	1			2.2
Hyaena		3	2		5.4
Jackal		7	6		14.1
Langur		2	1		3.3
Nilgai		3	2		5.4
Peafowl		9	3		13.0
Porcupine		1	1		2.2
Rodent	1	4	4		9.8
Sambar	1	3	2		6.5

Automatically triggered cameras are very effective in the survey of carnivores which are difficult to observe in the forest and occur in low abundance. One camera trap was used for a period of six days in the different areas of Sariska Range. During this period of survey, one leopard (male) was photographed in Tarunda (Appendix – 3). Apart from this a hyaena and a wild pig were also photographed near Khalighati.

Most of the cat species are considered to be very sensitive to biotic interferences. Johnsingh *et al.* (2004) reported that prey species and tiger usually avoided areas of human activities in Terai Arc Landscape, India. In a study on tiger undertaken in the Royal Chitwan National Park (RCNP), Nepal, Sunquist (1981) concluded that tiger preferred dense vegetation with widely distributed water sources, and a higher prey density and biomass. Carbone and Gittleman (2002) estimated that 30,300 kg/100 sq km of prey biomass can support density of one tiger/100 sq. km. The tiger density of one tiger/100 sq. km. was

reported from Ranthambore Tiger Reserve, which is very similar to Sariska. Seasonal differences in habitat use by tigers had been reported in RCNP due to changes in the conditions conducive for making kills. Unsuccessful stalking by tiger was also reported in the same study when the grass cover was < 30 cm height. Thus, the study could clearly explain the need of good ground cover for survival of tiger. We observed that severe livestock grazing in STR has greatly reduced the available grass cover. The observed average grass height around Haripura village located in National Park was <1.1 cm. The habitats found around other villages in Sariska also had similar ground conditions.

Mukherjee and Goyal (1998) studied the responses of lesser carnivores to habitat characteristics and level of disturbance in STR. The study reported that disturbance (human) is negatively correlated with 'Encounter Rate' of jungle cat distribution and abundance of its prey species. We feel that it is not only tiger which is affected in STR, but jungle cat and caracal too have also been affected due to severe livestock grazing, since we encountered very few scats of lesser carnivores during the course of field work. It is recommended that a detailed study on the status of lesser cats in STR needs to be undertaken at the earliest.

The biotic interference in the form of wood cutting, lopping and grazing was very high in Talviriksh Range, followed by Akbarpur Range, Tehla Range and Sariska Range (Figure 3 & 4). There has been a drastic increase in the livestock population recorded from Umri and Haripura villages and especially the goats (Table 5).

**Table 5. Per cent increase in livestock population from 1988 and 2004 in Umri and Hari-pura villages**

Livestock category	Umri			Haripura		
	1988	2004	Percent increase	1988	2004	Percent increase
Buffalo	152	481	216	180	433	140
Cattle	15	28	86	12	51	325
Goat	52	899	1628	48	631	1214

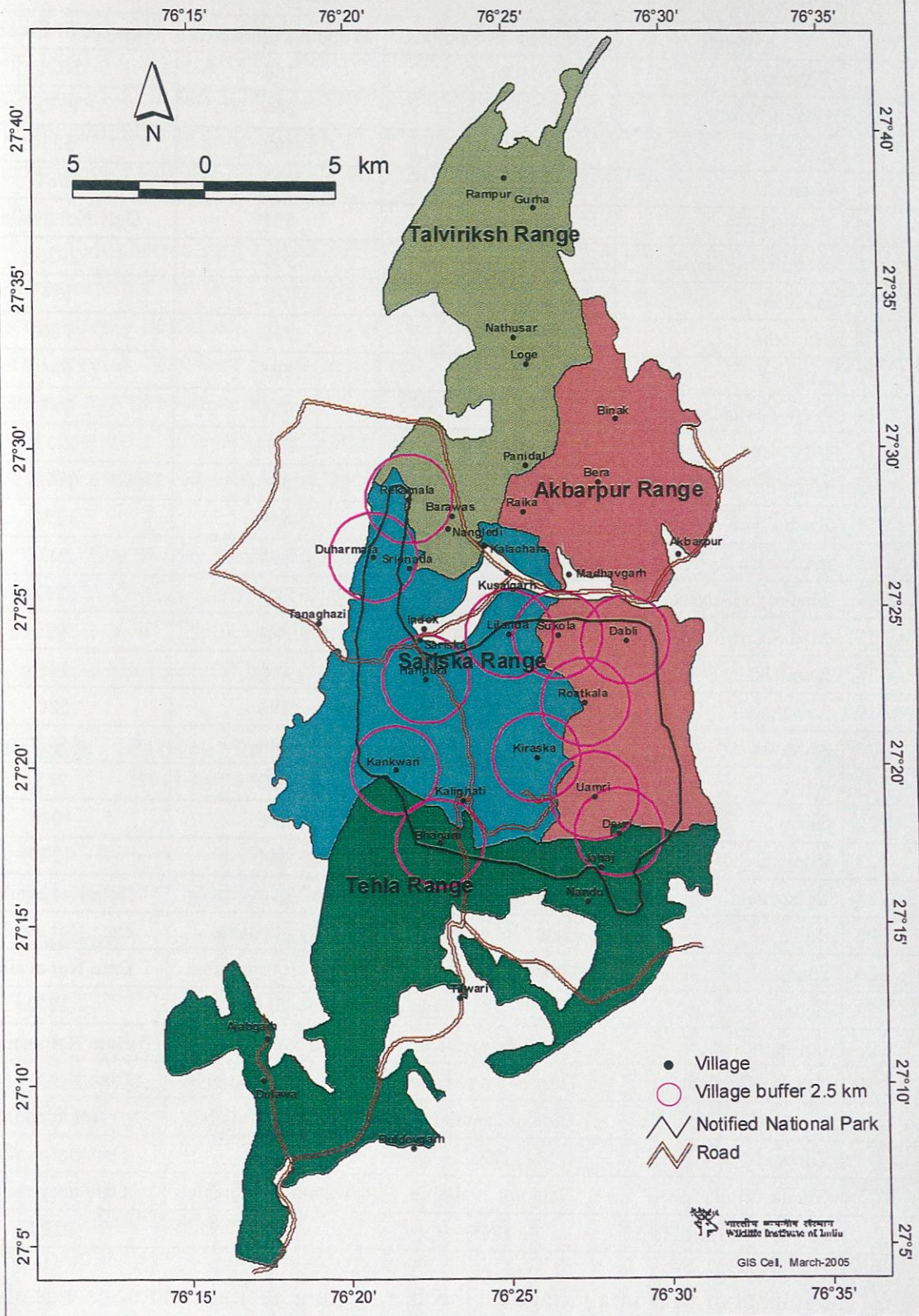
The estimated livestock and human population in the entire Tiger Reserve are given in Table 6. Nearly 32,000 livestock graze/browse inside the Tiger Reserve everyday.

**Table 6. Human and livestock population in villages in Sariska Tiger Reserve during 1998 (Source: Management Plan, STR).**

Sl No.	Village	Number of families	Human Population	Number of Livestock
1	Rekamala	84	158	2021
2	Daabli-Rotkala	59	304	1073
3	Sukola	28	192	625
4	Kiraska	127	533	1664
5	Umri-Devri	158	591	Data Not available
6	Kankwari-Pilapani	86	461	2835
7	Bhagani	18	71	134
8	Haripura	52	169	756
10	Lilunda	10	165	634
11	Naya Kundalka	68	164	788
12	Bhyrawas	172	1031	3215
13	Nangledi	72	334	3702
14	Kushalgarh	66	451	1291
15	Kalachara	22	135	507
16	Madhogarh-Indhok	264	1550	5212
17	Madhogarh-Indhok	57	324	1923
18	Kundalka	15	115	143
19	Lawakabas	33	194	580
20	Mitrawat	121	644	562
21	Rajor	48	310	745
22	Garh	25	176	1048
23	Dapkan	73	561	1277
24	Duharmala	Data Not available	Data Not available	Data Not available
25	Raika	Data Not available	Not available	Data Not available
26	Panidhal	Data Not available	Data Not available	Data Not available
27	Bera	78	531	2212
28	Loj-nathusar	Data Not available	Data Not available	Data Not available
29	Guada - Dhulawa	Data Not available	Data Not available	Data Not available
30	Guada - Bandipul	Data not available	Data not available	Not available
31	Thilwadi	19	108	Data not available
32	Guada - Bhomighati	Data not available	Data not available	Data not available
<b>Grand Total</b>		<b>1755</b>	<b>9272</b>	<b>32947</b>

The impact of Haripura village on the surrounding habitat conditions was observed to extend to a radius of 2.5 km radius. Keeping Haripura as a model, a 2.5 km radius zone was created around all villages located inside the National Park in order to get a picture of biotic interference (Map 8).

**Map 8 Impact of Villages on surrounding Habitat in Core Zone - I of Sariska Tiger Reserve**



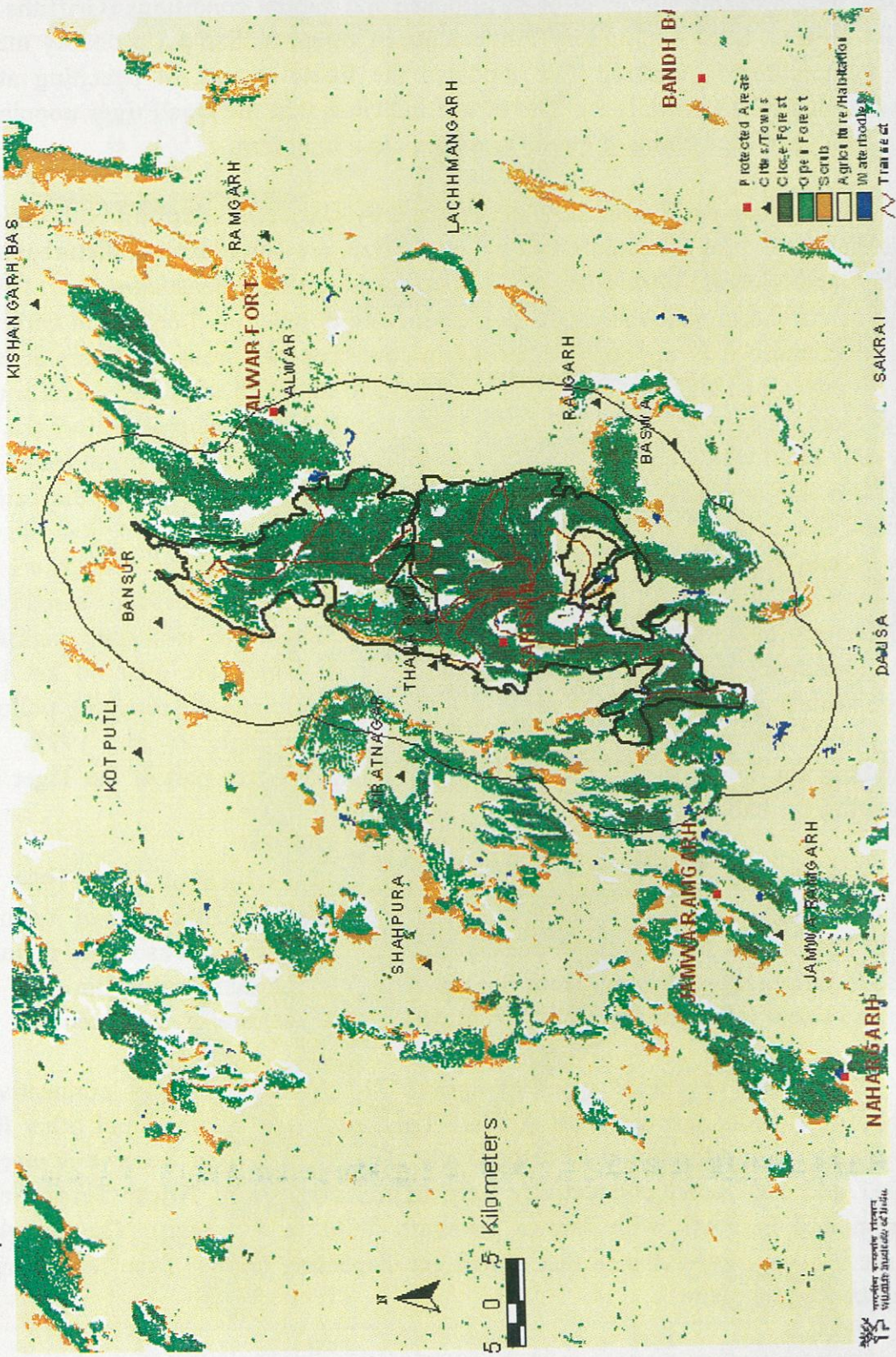
It is evident that there is very little undisturbed habitat left (<15%) in the National Park (Map 8). Studies on carnivores have reported an increase in exploratory movements by them due to changes in level of disturbance and habitat conditions (Griffiths and Van Schaik, 1992). Such exploratory movements of tigers in Sariska probably made them more vulnerable to poaching. We modeled the likely impact of poaching at various scenarios in STR (Appendix 1). The model indicates that the small tiger population will not sustain yearly poaching of one to two tigers in a long term.

Mammalian carnivores are characterized by classic relationship with their prey. It seems that carnivores are closely tied with prey size, prey biomass and disturbance factors (Karanth and Nichols, 1998; Carbone and Gittleman, 2002; Sidensticker *et al.* 1999). Prey density is critical to maintenance of large carnivore population. Looking at current socio-political scenario it is important to maintain core-breeding areas for tigers at landscape level. In any given National Park, it is important to maintain mini-cores as a source area for tiger and its prey. In Sariska Tiger Reserve, the Sariska-Pandupole valley (ca. 80 km<sup>2</sup>) is the only area, which can be considered as mini-core. The reported presence of breeding tigress in this area indicate relatively undisturbed core. As the rest of the park area is disturbed due to anthropogenic pressures they have very low wild ungulate density and hence it can support only a few tigers (Johnsingh *et al.*, 1997). The future of tiger population was reported to be insecure due to immense biotic pressure caused by human and livestock population (Johnsingh *et al.*, 1997). There are two state highways: the Alwar-Thanagazi-Jaipur and Sariska-Kalighati-Tehla, which are over 44 km in length traversing through the National Park. The vehicular traffic and the resulting pollution and noise cause enormous disturbance to wildlife (Johnsingh *et al.*, 1997). Mining, particularly for dolomite, is a serious problem in the southern part of the Tiger Reserve, threatening the habitat in the Reserve.

Eleven villages located in this area are due for relocation since 1984 (Sankar, 1994; Johnsingh *et al.*, 1997). Johnsingh *et al.* (1997) reported that part of National Park (ca.120 km<sup>2</sup>) could sustain a high density of prey species and a reasonable population of tigers. Extermination of tigers from Sariska will alter the distribution limits of tigers in India and likely influence the ecological structure of the semi-arid ecosystem.

The broad vegetation types of Sariska Tiger Reserve and its connectivity with neighboring forests and the West Aravalli Landscape of Rajasthan and other Protected Areas is shown in Map 9 and 10 respectively. The Sariska Tiger Reserve is more or less isolated and has forest connectivity only in the north with Alwar Territorial Forest Division and in south with Jamwa Ramgarh Wildlife Sanctuary. The Sariska Tiger Reserve has very little chance that it will get dispersing tiger(s) from neighboring tiger areas like Ranthambore.

Map 9 Broad Vegetation types of Sariska Tiger Reserve and its connectivity with neighbouring forests





To re-establish tiger population in Sariska it is important to remove disturbance factors affecting habitat condition and prey availability to tigers. Reintroduction should establish self-sustaining populations with high reproductive fitness in the wild environment and ample genetic diversity (Frankham *et. al.* 2002). It is suggested that a tigress from Keoladeo Ghana National Park, Bharatpur and few individuals (2 females and 2 males) from buffer of Ranthambore National Park can be brought to re-establish the tiger population in Kalighati area of Sariska Tiger Reserve. The visualized scenario for the growth of re-introduced tiger population in STR is given in Appendix 2. It is also recommended that the reintroduced tigers should be radio-collared and monitored for their long-term survival.

## 8. FINDINGS & RECOMMENDATIONS

- a) We did not come across any tiger evidences (direct sighting, indirect evidences such as pugmarks, scats and scrap marks) during the study. It is reported that from all areas used by tigers in 2002-2003 (Avinandan 2003), we found only leopard tracks and signs. In total, only 13 individual tracks and fifteen scats (fresh and old) of leopards were encountered during the present study. Immediate attention needs to be given by the park authorities to monitor the status of leopard population in Sariska. Indirect evidences (droppings/tracks) of jungle cat (*Felis chaus*) and caracal (*Felis caracal*) were not observed during the present study. This aspect also requires further scientific evaluation.
- b) The number of tiger sightings reported by the tourists and forest staff in the Tiger Reserve from 1997 to 2004 has shown declining trend since 1999. Based on the available secondary information it is evident that the total number of tiger sightings observed was on the downward trend in Sariska since 1999 but the park management consistently reported the tiger population ranging between 24 and 27.
- c) Except in Sariska range, the encounter rate observed for wild prey species of tigers (chital, sambar, nilgai, langur, wild pig) was very low in other Ranges (Akbarpur, Tehla and Talviriksh). The encounter rate of domestic livestock observed was very high in all the four ranges in Sariska Tiger Reserve as compared to the wild prey base. Of all the ranges, only the Sariska range has the potential to sustain breeding units of tiger. The other Ranges can hold only dispersing or displaced tigers due to high level of anthropogenic disturbance and low wild prey population.
- d) The quantified information on biotic pressure in the form of Wood Cutting, Lopping and Grazing was very high in Talviriksh Range, followed by Akbarpur Range, Tehla Range and Sariska Range.

- e) There are two state highways: Alwar-Thanagazhi-Jaipur and Sariska-Kalighati-Tehla, which are over 44 km in length and traverse through the National Park. The vehicular traffic result in enormous disturbance to wildlife. The vehicular traffic from Alwar to Thanagazi via Sariska needs to be diverted through Kushalgarh – Talviriksh metallic road. Similarly vehicular traffic from Sariska to Tehla via Kalighati needs to be diverted through Kushalgarh – Talviriksh – Thanagazi – Kishori metallic road. The pilgrims heading for Pandupole temple during Tuesdays and Saturdays via Sariska – Kalighati metallic road should be diverted through Bhartahri – Kiraska – Pandupole non-metallic road. Mining, particularly for dolomite is a serious problem in the southern part of the Tiger Reserve, threatening the habitat in the Reserve and needs to be stopped completely.
- f) There are 11 villages located in this area and for relocation since 1984. It is evident from the present study that there is little (<15%) undisturbed habitat available in National Park. We suggest immediate translocation of Haripura, Umri, Kankawari (Kankawari, Peelapani, Kadat), and Kiraska. The remaining villages should also be relocated in a phased manner.
- g) Sariska Tiger Reserve is one of the western most limits of tiger distribution in India. Wickramanayake *et al* (1999) classified Sariska Tiger Reserve as Tiger Conservation Unit – 3 (TCU 3) among the dry deciduous habitat types. Extermination of tigers from Sariska would alter the distribution limits of tigers in India which may likely influence the ecological structure of the semi-arid ecosystem.
- g) The Sariska Tiger Reserve is more or less isolated and has forest connectivity only in the north with Alwar Territorial Forest Division and in south with Jamwa Ramgarh Wildlife Sanctuary. Sariska has very little chance that it will get dispersing tiger(s) from the neighboring tiger areas like Ranthambore Tiger Reserve. Therefore a comprehensive tiger population revival strategy needs to be developed immediately and implemented. Appendix 2 indicates the proposed population growth pattern of reintroduced tigers (3 females and 2 males) and subsequent addition of tigers at an interval of three years for maintaining genetic vigour. While preparing such plans there is a need to implement the concepts of managing small and isolated carnivore populations.

## 9. SCOPE OF FUTURE WORK

As per the mandate given to WII by the Project Tiger authorities, this study addressed objective No. 1 "The evaluation of the status of tigers in Sariska Tiger Reserve", since this information was urgently required. A detailed proposal for the remaining objectives as mentioned below will be prepared and submitted to the Director, Project Tiger:

1. Distribution and status of leopard and small carnivores.
2. Distribution and status of prey animals.
3. Vegetation and land cover map.
4. Anthropogenic pressure on forest land.
5. Study on socio-economic profile and resource dependency of local people.
6. An outline for the Management Plan for Sariska.

## 10. REFERENCES

- Anon (2003). Census report of wild animals in Sariska Tiger Reserve. Unpublished. Office of the Field Director, Sariska Tiger Reserve, Rajasthan.
- Anon (2004). Census report of wild animals in Sariska Tiger Reserve. Unpublished. Office of the Field Director, Sariska Tiger Reserve, Rajasthan.
- Avinandan, D. (2003). Food habits of tiger (*Panthera tigris tigris*) in Sariska Tiger Reserve, Rajasthan. M.Sc. Dissertation, Saurashtra University, Rajkot. 50 pp.
- Bagchi, S., S.P. Goyal and K. Sankar. (2003). Prey abundance and prey selection by tigers (*Panthera tigris*) in a semi-arid, dry deciduous forest in western India. *J.Zool.Lond*, (260):285-290.
- Bailey, T.N. (1993). The African leopard:ecology and behaviour of a solitary felid. Columbia University Press, New York.
- Biswas, S. and K.Sankar. (2002). Prey abundance and food habit of tigers (*Panthera tigris tigris*) in Pench National Park, Madhya Pradesh, India. *J.Zool.Lond*, (256):411-420.
- Carbone Chris and John C. Gittleman (2002). A common rule for scaling of carnivore density. *Science*, (295):2273-2276.
- Champion, H.G and Seth, S.K. (1968). The Forest Types of India. Delhi: The Government of India press, New Delhi.
- Choudhary, S.R. (1972). Tiger census in India. *Cheetal*, 15 (1):67-77.
- Corbett. J. (1944). The man-eaters of Kumaon, Oxford University Press.
- Frankham, R., J. D. Ballou and D. A. Briscoe (2002) Introduction to conservation genetics. Cambridge University Press.
- Gogate, N. and Chundawat,R.S. (1997). Ecology of Tigers to enable realistic projection of the requirement needed to maintain a demographically viable population in India. 2<sup>nd</sup> progress report. Wildlife Institute of India , Dehra Dun.
- Griffiths, M and Van Schaik, C.P. (1992). The impact of human traffic on the abundance and activity periods of Sumatran Rain forest Wildlife. *Conservation Biology*, Vol. 7 (3): 623-626
- Johnsingh,A.J.T. (1983). Large mammalian prey-predator in Bandipur. *Journal Bombay Nat. Hist. Soc.* 80:1-57.

- Johnsingh, A.J.T., Goyal, S.P., Rawat, G.S., Mukherjee, S. (1993). Food habits of tiger and leopard in Rajaji National Park, North West India. Abstract presented at International Tiger Symposium on the Tiger, 22<sup>nd</sup> to 24<sup>th</sup> February 1993, New Delhi.
- Johnsingh, A.J.T., Ramesh, K., Qureshi, Q., David, A., Goyal, S.P., Rawat, G.S., Rajapandian, K., and Prasad, S. (2004). Conservation status of tiger and associated species in the Terai Arc Landscape, India. RR-04/001, Wildlife Institute of India, Dehra Dun. Pp. viii + 110.
- Johnsingh, A.J.T., Sankar, K., and Mukherjee, S. (1997). Saving the prime tiger habitat in Sariska Tiger Reserve. *Cat News*. 27-Autumn, 1997.
- Karanth, K.U. (1991). Ecology and management of Tigers in Tropical Asia. Pg 156-159. In: Maruyama, B. Bobek, Y. Ono, W. Regelin, L. Bartos and R. Ratcliffe (ed.) *Wildlife Conservation: Present trends and perspectives for the 21<sup>st</sup> century*. Japan Wildlife Research Center, Tokyo.
- Karanth, K.U. (1993). Predator-Prey relationship among large mammals of Nagarhole National Park, Ph.D. Thesis. Mangalore University.
- Karanth, K. U., Nichols, J. D., Kumar, N. S., Link, W. A. & Hines, J. E. (2004). Tigers and their prey: predicting carnivore densities from prey abundance. *Proc. Nat. Acad. Sci. USA* 101: 4854-4858.
- Karanth, K.U and Sunquist, M.E. (1995). Prey Selection by tiger, leopard and dhole in tropical forests. *Jour. Anim. Ecol.* 64, 439-450.
- Lacy, R.C. (1999) Vortex [WWW document]. <http://pwl.netcom.com/~rlacy/vortex.html>.
- Mathur, V.B. (1991). The ecological interaction between habitat composition, habitat quality and abundance of some wild ungulates in India. Ph. D. Thesis, University of Oxford, U.K. 279 Pp.
- Mazak, V. (1981) *Panthera tigris*. *Mammalian Species*, 152, 1-8.
- Miller, P.S. and Lacy, R.C. (1999) Vortex: a stochastic simulation of the extinction process, Version 8, Users manual, Conservation Breeding Specialist Group. (SSC/IUCN): Apple Valley, MN.
- Mukherjee, S., and Goyal, S.P. (1998). Habitat use by sympatric small carnivores in Sariska Tiger Reserve, Rajasthan, India. Final Report. Wildlife Institute of India, Dehra Dun, India.
- Panwar, H.S. (1979). Population dynamics and land tenures of tigers in Kanha National Park, *Indian Forester (Special Issue)*, 18-36.

Panwar, H.S. (1979). A note on tiger census techniques based on pugmark tracing. Tiger Paper 6:16-18.

Pascoe, E.H. (1950). Manual of the geology of India and Burma. Govt of India, Manager of Publ., Calcutta, Vol. I: 1-483.

Rodgers, W.A and Panwar, H.S. (1988). Planning a Wildlife Protected Area Network in India (Vol I & II) Wildlife Institute of India, Dehra Dun.

Sankar, K. (1994). Ecology of three large sympatric herbivores (Chital Sambar, Nilgai) with reference to reserve management in Sariska Tiger Reserve, Rajasthan. Ph.D. Thesis, University of Rajasthan, Jaipur, India.

Sankar, K and A.J.T. Johnsingh. (2002). Food habits of tiger (*Panthera tigris*) and leopard (*Panthera pardus*) in Sariska Tiger Reserve, Rajasthan, India, as shown by scat analysis. Mammalia 66(2):285-289.

Sankhala, K. (1977). Tiger: The story of Indian Tiger. New York: Simon and Schuster.

Schaller, G.B. (1967). The Deer and the Tiger: A study of Wildlife in India. University of Chicago Press, Chicago.

Seidensticker, J. (1976). Ungulate populations in Chitwan valley, Nepal. Biol. Conserv. 10:183-209.

Seidensticker, J., S. Christi and P. Jackson, editors (1999). Riding the tiger: Tiger conservation in human-dominated landscape. Cambridge University Press.

Shankarnarayanan, P., Banerjee, M., Kaiker, R.K., Agarwal, R.K. and Singh, L. (1997). Genetic variation in Asiatic Lions and Indian Tigers. Electrophoresis, 18, 1693-1700.

Singh, A. (1984). Tiger! Tiger! Jonathan Cape, London.

Smith, J.L.D. (1993). The Role of dispersal in structuring the Chitwan tiger population. Behaviour. 124:165-195.

Smith, J.L.D, Mc Dougal, C, & Sunquist, M.E. (1987). Female land tenure system in tigers. Pg 97-109. In Ronald L. Tilson & Ulysses S. Seal (ed.). Tigers of the World: The Biology, Biopolitics, Management and conservation of an endangered species. Noyes Pub. New Jersey.

Stoen, O. (1994). The status and food habit of the tigers (*Panthera tigris*) population in Karnali floodplain of Royal Bardia National Park, Nepal. M.Sc. Thesis. Agricultural University, Norway.

- Sunquist, M.E. (1981). The social organization of tigers (*Panthera tigris*) in Royal Chitwan National Park. Smithsonian Contribution to Zoology. 336,1-98.
- Sunquist, M. and Sunquist, F. (2002) Wild cats of the world. University of Chicago Press, Chicago.
- Tamang, K.M.(1983). The status of the tiger (*Panthera tigris tigris*) and its impact on principal prey populations in the Royal Chitwan National Park, Nepal. Ph.D, Dissertation, Michagan State University, East Lansing, Michagan.
- Thapar, V.(1986). Tiger: Portrait of a predator. Collins, London.
- Thapar, V.(1989.) Tigers: The secret life. Elm Tree books. London.
- Vanak, A. (1997). Movement Patterns of Radio-tagged Tigers in Panna National Park, M.P. M.Sc. Dissertation. Saurashtra University, Rajkot.
- Wikramanayaka, E.D., Dinerstein, E. Robinson, J.G., Karanth, K.U., Rabinowitz, A., Olson, D., Mathews, T., Hedao, P., Connor, M., Hemley, G., and Bolze, D. (1999). People, tiger habitat availability, and linkages for the tiger's future. In: (Eds. Seidensticker, J., Christie, S. and Jackson, P.). Riding the tiger Tiger conservation in human-dominated landscapes. Cambridge University Press. Pp-255-272.
- Wilkinson, D.M. and H.J. O'Regan (2003). Modeling differential extinctions to understand big cat distribution on Indonesian islands. Global Ecology & Biogeography 13,519-524.
- Zielinski, W.J. and Kucera, T.E. (1995). Survey methods for the detection of wolverines, lynx, fishers and martens. USDA Forest Service General Technical Report PSW-157.

**Projected tiger population, population growth pattern and extinction rates for Sariska Tiger Reserve.**

The population of tigers in Sariska was reported to be ranging between 24 and 26 from 1996 to 2003 (Anon, 2003, 2004). The tigers were largely distributed within 274 km<sup>2</sup> of the National Park. The best tiger habitat, classified on the basis of wild prey availability is approximately 80 km<sup>2</sup>. The surrounding area is taken to be medium to poor quality habitat. The population is estimated on the basis of Tiger- Prey relationship equation (Fig.5.) (Karanth *et. al.* 2004).

$$T_j = A U_j^b \delta_j$$

Where A = 0.247 (95% confidence interval 0.181 to 0.336)  $U_j$  = Prey density/km<sup>2</sup>, b= 1 and  $\delta_j=1$

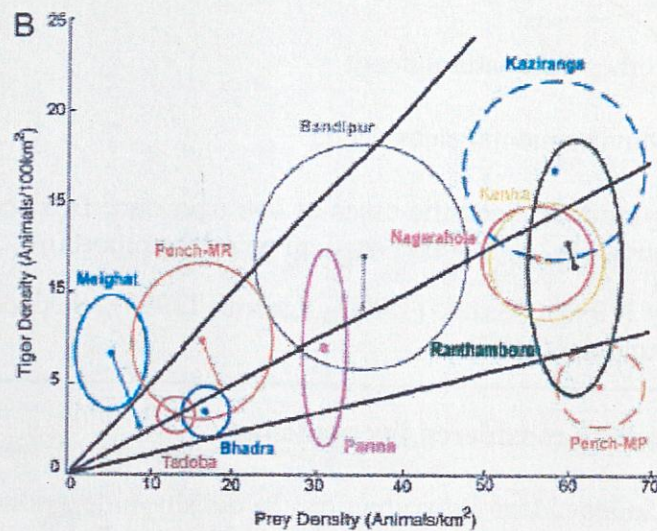


Fig. 5. The relationship between prey and tiger abundance (Karanth *et. al.* 2004).

Sariska can possibly support approximately 15 individuals (95% Confidence Interval 10 to 21) based on tiger-prey equation (Karanth *et. al.* 2004). The given condition in Sariska will not support a population of 26 tigers. We modeled the growth pattern of tiger population based on the parameters given in table 1. The population parameters (Table 1) used for modeling population are largely derived from literature. Due to absence of information on age specific survivorship we used the stable age distribution. Vortex (Lacy, 1999) and 'Ramasage' were used to model population growth pattern. The population was simulated 500 times. We modeled population with equal sex ratio at birth and default value of 1.57 recessive lethal allele and 1.57 lethal equivalent not subjected to removal (Miller and Lacy 1999, Wilkinson and O'Regan 2003) was used to model inbreeding in VORTEX. We presumed 35 percent of males in breeding pool and 50 percent of females breeding in any given year. We also used environmental catastrophe which may occur at 3 to 5 years interval with varying intensity (probability of 0.2/year) causing prey depletion. The simulations were done with and without constraints.

**Table 1 Tiger Life history data used in modeling population growth pattern.**

Tiger Litter size (%)
1 40
2 25
3 25
4 10
Cub mortality (%) 50 each in male and female
Adult mortality (%) 10 each in male and female
<i>K</i> , Carrying capacity 20 tigers
Maximum breeding age 15
Start of breeding
Males 4
Females 3
Mortality Factors other than natural death
a) Death to due environmental catastrophe
b) Poaching varying from sporadic cases of one tiger once in a year to 4 tigers every year (between 2001-2 and 2004 based on poaching reports).
<i>Reference:</i> Bailey (1993), Mazak (1981), Karanth (1999), Seidenticker <i>et al</i> (1999) and Sunquist & Sunquist (2002).

**Following scenarios were considered for modeling:**

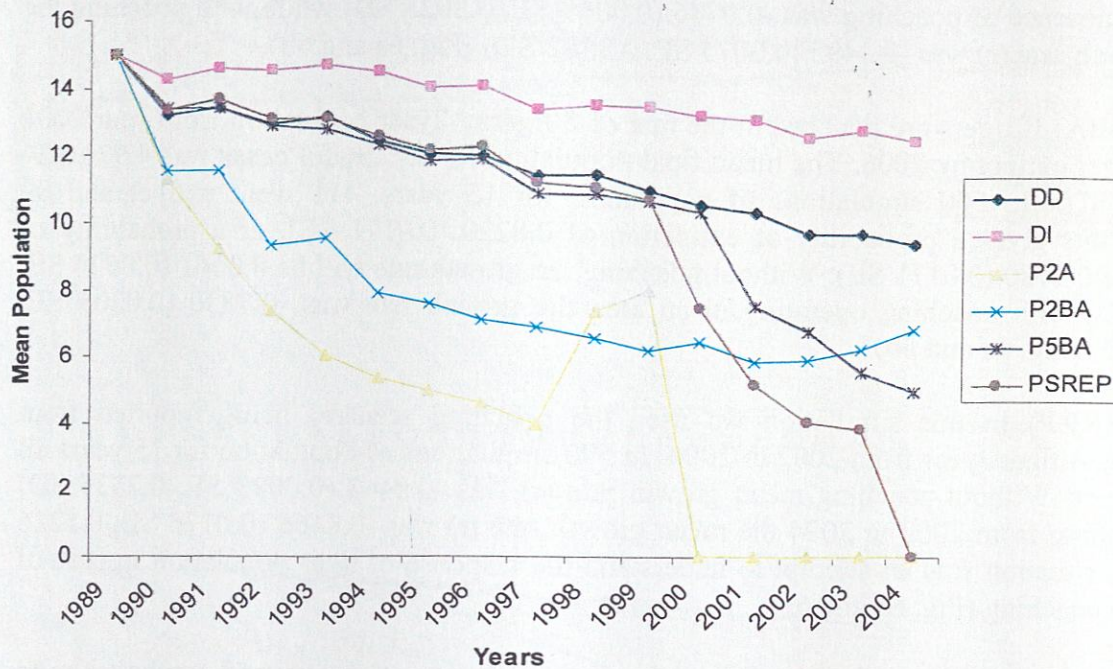
**DI)** Density Independent Reproduction: In density independent model population in 2004 was 12 (0.23 SE, 4.96 SD) with maximum chance of extinction being one percent (0.0135 SE). The probability of survival was 0.8980 (0.0135 SE). Deterministic population growth rate, based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression was,  $r = 0.003$ ,  $\lambda = 1.003$  and  $R_0 = 1.024$ . The mean population growth rate prior to carrying capacity truncation was -0.0161 (0.0028 SE, 0.2440 SD). The observed heterozygosity was 0.9623 (0.0030 SE, 0.0636 SD). The mean time to first extinction was 11.96 years (0.31 SE, 2.18 SD) (Fig. 6a and 6b).

**DD)** In density dependent model population by 2004 would be 9 (0.22 SE, 4.59 SD). In 500 simulations of Population for 15 years 77 went extinct and 423 survived. The Probability of extinction of 0.1540 (0.0161 SE) or a probability of survival of 0.8460 (0.0161 SE) was observed. Deterministic population growth rate (based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression) was  $r = 0.014$ ,  $\lambda = 1.014$  and  $R_0 = 1.122$ . The mean time to first extinction was 11.64 years (0.30 SE, 2.63 SD). The mean population growth rate prior to carrying capacity truncation was -0.0497 (0.0029 SE, 0.2455 SD). The observed heterozygosity was 0.9617 (0.0036 SE, 0.0736 SD) (Fig. 6a and 6b).

**P2A & P2BA)** We have modeled two scenarios 2 tigers (1 male and 1 female) poached every year and one tiger (either male or female) poached every year. In case of 2

tiger/year being poached, the tiger population becomes extinct by year 2001. No population survives in the given time frame of 25 years and mean time to first extinction was 5.13 years (0.07 SE, 1.53 SD) (Fig. 6a and 6b).

6a



6b

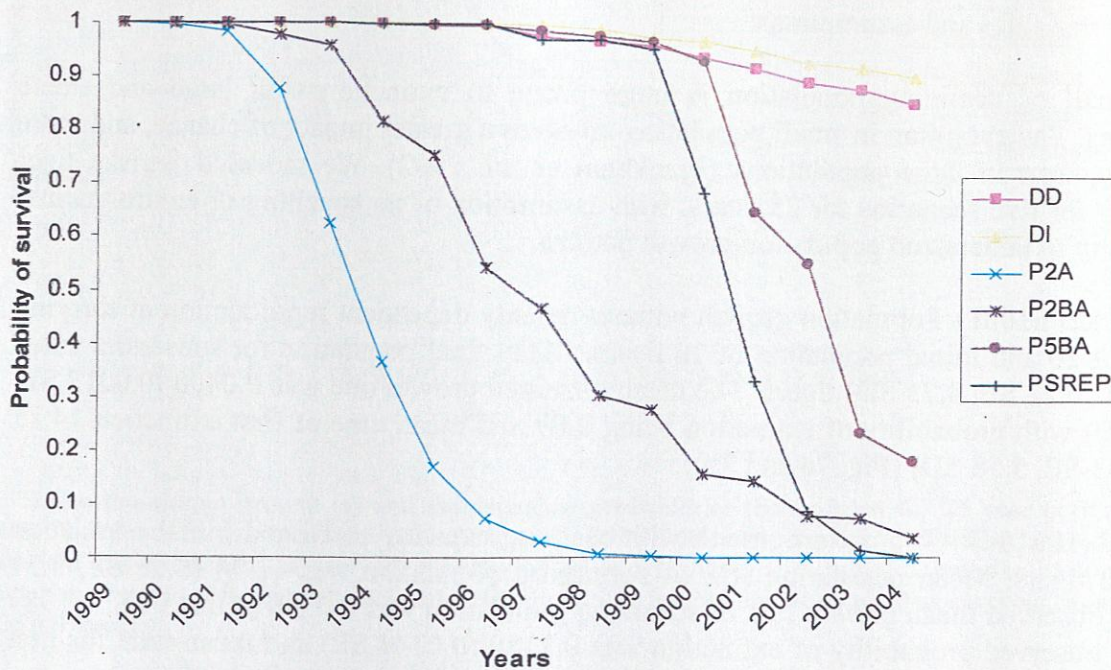


Fig. 6. The Population growth (a) and survivorship probabilities (b) modeled for Sariska tiger population. The density independent (DI) and density dependent (DD) population growth and simulation of extinction due to poaching, two tiger/year (P2A), one tiger/year (P2BA), 5 tigers from 2002 to 2004 / 2 years (P5BA) and 4 tigers from 2002/year.

The mean growth rate ( $r$ ) was  $-0.4062$  ( $0.0078$  SE,  $0.3897$  SD) with poaching operating on annual basis (Fig. 6a and 6b).

If one tiger was poached/year the population would be  $6.78$  ( $0.90$  SE,  $3.81$  SD). In 500 simulations of Population for 15 years 482 went extinct and 18 survived, this gives a probability of extinction of  $0.9640$  ( $0.0083$  SE), or a probability of survival of  $0.0360$  ( $0.0083$  SE). The mean time to first extinction was  $8.29$  years ( $0.13$  SE,  $2.83$  SD). The mean growth rate ( $r$ ) in absence of poaching was  $-0.0786$  ( $0.0069$  SE,  $0.3025$  SD) while with poaching the mean growth rate ( $r$ ) was  $-0.3495$  ( $0.0075$  SE,  $0.3582$  SD) (Fig. 6a and 6b).

**P5BA)** If tigers are poached at the rate of 5 tigers / 2year population from year 2001 they will get extinct by 2006. The mean final population for successful cases was  $4.97$  ( $0.24$  SE,  $2.22$  SD). In 500 simulations of population for 15 years, 411 went extinct and 89 survived, this gives a probability of extinction of  $0.8220$  ( $0.0171$  SE), or a probability of survival of  $0.1780$  ( $0.0171$  SE). Without poaching the growth rate will be  $0.0661$  ( $0.0034$  SE,  $0.2619$  SD) with poaching operating in an area the growth rate was  $-0.7830$  ( $0.0205$  SE,  $0.5203$  SD) (Fig. 6a and 6b).

**PSREP)** In this simulation we used the poaching scenario being reported from Sariska i.e. 4 tigers/year from 2002 to 2004. In 500 simulations of Population for 15 years all went extinct. Without poaching mean growth rate ( $r$ ) was  $-0.0443$  ( $0.0033$  SE,  $0.2335$  SD) with poaching from 2002 to 2004 the mean growth rate ( $r$ ) was  $-0.8466$  ( $0.0176$  SE,  $0.5226$  SD). This situation was an attempt to understand the response of tiger population in case of excessive poaching (Fig. 6a and 6b).

Our attempt to model extinction of tiger in Sariska is exploratory and can be taken as the approach to understand the sensitivity of population to various ecological parameters. This exercise can operate within the constraints of data available for life history and other ecological variables and assumptions.

Small or declining population is more prone to extinction than large and stable populations. The evolution in small population involves a greater impact of chance, and more inbreeding, than in large populations (Frankham *et. al.* 2002). We modeled Sariska tiger population for five scenarios for 25 years, with assumption of no poaching or environmental stochasticity to understand population growth pattern.

1) **k20n10di** - Population growth without density dependent reproduction at carrying capacity of 20 and initial population of 10 tigers. Mean final population for successful cases was  $15.84$  ( $0.22$  SE,  $4.73$  SD) tigers. The mean observed growth rate was  $0.0400$  ( $0.0017$  SE,  $0.1888$  SD) with probability of extinction being  $0.09$  and mean time of first extinction  $14.73$  years ( $0.83$  SE,  $5.58$  SD) (Fig. 7a and 7b).

2) **k15n10di** - Population growth with carrying capacity of 15 and initial population size of 10 tigers. Mean population size of successful population was  $11.94$  ( $0.16$  SE,  $3.31$  SD). The observed mean growth rate of surviving population was  $0.0398$  ( $0.0018$  SE,  $0.1989$  SD). The observed probability of extinction was  $0.1180$  ( $0.0144$  SE) and mean time for first extinction was  $15.42$  years ( $0.76$  SE,  $5.86$  SD) (Fig. 7a and 7b).

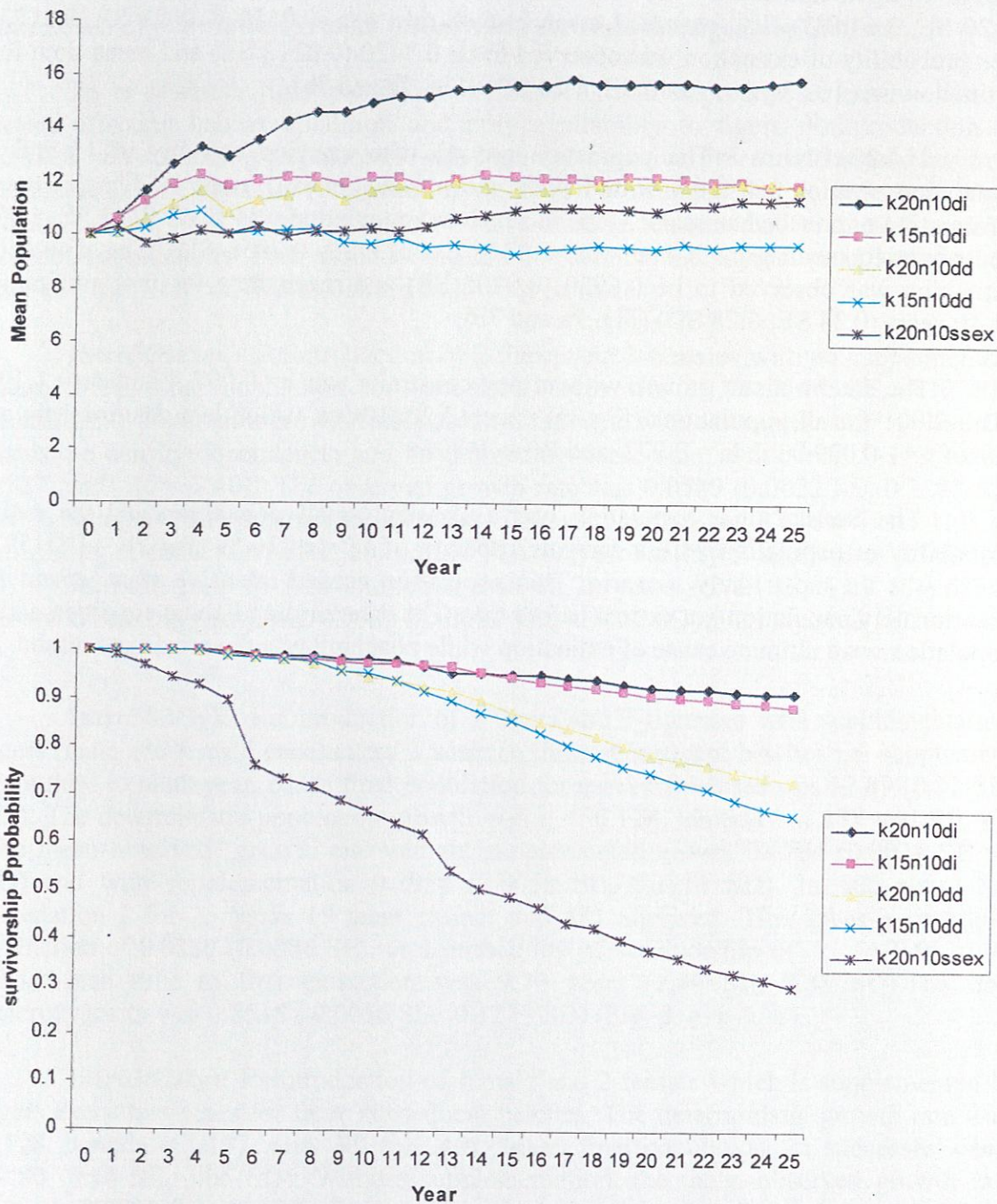


Fig. 7: The Population growth (a) and survivorship probabilities (b) modeled for 25 year period. The density independent reproduction (k20n10di and k15n19di) and density dependent reproduction (k20n10dd and k15n10dd) at carrying capacity of 20 and 15 tigers with initial population of 10 tigers. Population of tigers with sex ratio of 5 male/ female having initial population of 10 at carrying capacity of 20 (k20n10ssex).

3) k20n15dd) – Population growth with carrying capacity of 20 and initial population size of 10 tigers and density dependent reproduction. Mean population size was 11.82 (0.26 SE, 4.99 SD). The observed mean growth rate was -0.0090 (0.0020 SE, 0.2093 SD). The probability of extinction was observed to be 0.2720 (0.0199 SE) and mean time for first extinction was 15.75 years (0.46 SE, 5.38 SD) (Fig. 7a and 7b).

4) **k15n10dd** - Population growth with carrying capacity of 15 and initial population size of 10 tigers and density dependent reproduction. Mean of surviving population was 9.74 (0.20 SE, 3.64 SD). The observed mean growth rate was -0.0150 (0.0021 SE, 0.2157 SD). The probability of extinction was observed to be 0.3420 (0.0212 SE) and mean time for first extinction was 16.33 years (0.40 SE, 5.26 SD) (Fig. 7a and 7b).

4) **k20n10ssex** - The population growth with carrying capacity of 15 and initial population size of 10 tigers with highly skewed sex ratio 5 male / female, based on information of poached animals. Mean of surviving population was 11.42 (0.41 SE, 5.07 SD). The observed mean growth rate was -0.0257 (0.0023 SE, 0.2058 SD). The probability of extinction was observed to be 0.6980 (0.0205 SE) and mean time for first extinction was 11.40 years (0.34 SE, 6.28 SD) (Fig. 7a and 7b).

The deterministic growth without any constraint was  $r = 0.097$ ,  $\Lambda = 1.105$  and  $R_0 = 2.001$  for all populations (Fig 3a) except k20n10ssex which had deterministic growth rate of  $r = -0.029$ ,  $\Lambda = 0.972$  and  $R_0 = 0.800$ .

The Sariska tiger population was a classical small population and the extinction probability of population with a carrying capacity of 15 was 26 % (Fig 7b - DD15K10N), which was the most likely scenario. This population needed intensive management inputs, unfortunately population got extinct before that. The deteriorating habitat condition and small population were ultimate cause of extinction while poaching was the proximate reason.

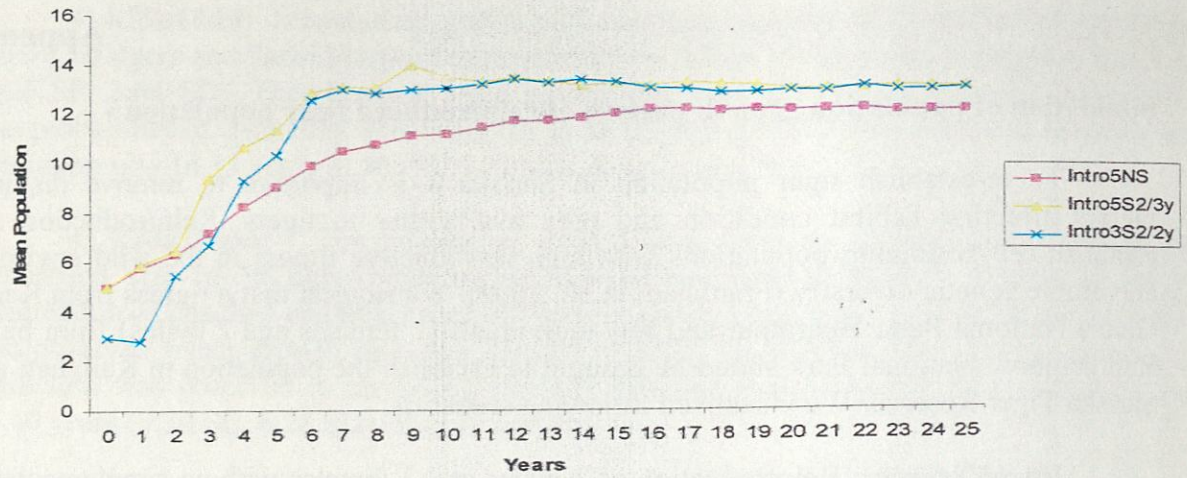
**Simulation of population growth pattern of reintroduced tiger population:**

To re-establish tiger population in Sariska it is important to remove disturbance factors affecting habitat condition and prey availability to tigers. Reintroduction should establish self-sustaining populations with high reproductive fitness in the wild environment and ample genetic diversity (Frankham et. al. 2002). We suggest that a tigress from Keoladeo Ghana National Park, Bharatpur and few individuals (2 females and 2 males) from buffer of Ranthambore National Park should be brought to establish the population in Kalighati area of Sariska Tiger Reserve. We visualized following scenarios:

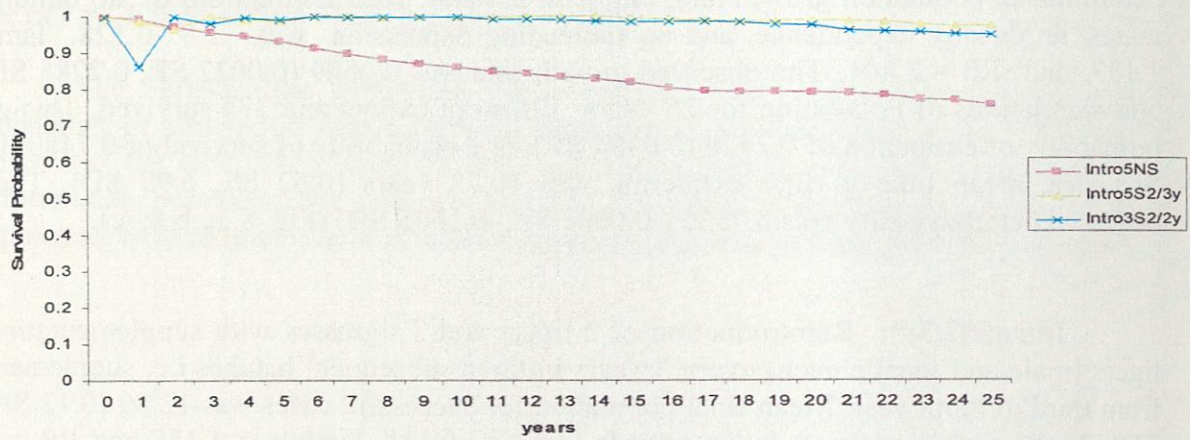
**Intro5Nsexeq):** Reintroduction of 2 males and 3 females with no supplementation in future. Mean final population for successful cases was 11.91 (0.17 SE, 3.32 SD). The deterministic population growth rate, based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression was  $r = 0.128$ ,  $\lambda = 1.137$  and  $R_0 = 2.401$ . The observed growth rate was 0.0589 (0.0022 SE, 0.2285 SD). In 500 simulations of Population for 25 years 126 went extinct and 374 survived. This gives a probability of extinction of 0.2520 (0.0194 SE), or a probability of survival of 0.7480 (0.0194 SE). The mean time to first extinction was 10.73 years (0.62 SE, 6.99 SD). The final observed heterozygosity was 0.7535 (0.0083 SE, 0.1605 SD) (Fig. 8. a, b & c).

**Intro5S2/3y):** Reintroduction of 2 tigers and 3 tigresses with supplementation of 2 tigers (male and female each) every 3 years in three subsequent batches i.e. supplementation from third to ninth year. Mean final population for successful cases was 12.89 (0.13 SE, 2.89 SD). The deterministic population growth was  $r = 0.128$ ,  $\lambda = 1.137$  and  $R_0 = 2.401$ . The mean observed growth rate without supplementation was 0.0784 (0.0021 SE, 0.2145 SD) and with supplementation 0.2954 (0.0058 SE, 0.2214 SD). In 500 simulations of Population 1 for 25 years 19 went extinct and 481 survived. This gives a probability of extinction of 0.0380 (0.0086 SE), or a probability of survivorship of 0.9620 (0.0086 SE). Mean time to first extinction was 9.70 years (1.40 SE, 8.88 SD). The observed heterozygosity was 0.8518 (0.0056 SE, 0.1237 SD) (Fig. 8. a, b & c).

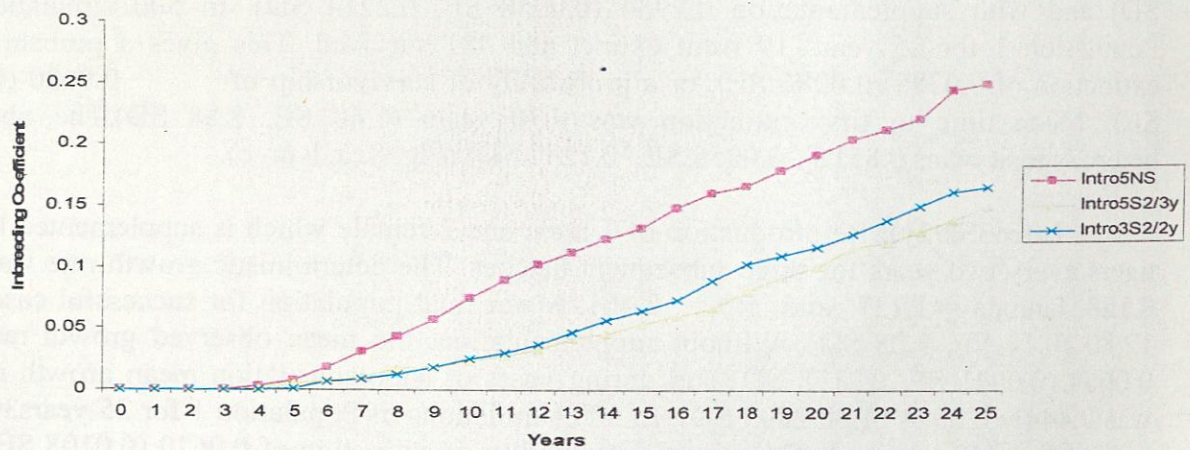
**Intro3S2/2y):** Reintroduction of 1 male and 2 female which is supplemented by two tigers every two years for three subsequent batches. The deterministic growth rate was,  $r = 0.128$ ,  $\lambda = 1.137$  and  $R_0 = 2.401$ . Mean final population for successful cases was 12.80 (0.14 SE, 3.05 SD). Without supplementation, the mean observed growth rate was 0.0664 (0.0021 SE, 0.2178 SD) and during years of supplementation mean growth rate ( $r$ ) was 0.4441 (0.0074 SE, 0.2803 SD). In 500 simulations of Population 1 for 25 years 31 went extinct and 469 survived. This gives a probability of extinction of 0.0620 (0.0108 SE), or a probability of survivorship of 0.9380 (0.0108 SE). The mean time to first extinction was 5.77 years (0.79 SE, 8.10 SD). Observed heterozygosity was 0.8369 (0.0062 SE, 0.1334 SD) (Fig. 8. a, b & c).



(a)



(b)



(c)

Fig. 8. : The Mean population growth (a); survival probability (b) and inbreeding co-efficient of reintroduction scenarios, Intro5NS- reintroduction of 2 males and 3 females with no supplementation, Intro5S2/3y – reintroduction of 2 tigers and three tigresses with supplementation of 2 tigers every 3 years and Intro3S2/2y – reintroduction of 1 male and 2 females and supplementation by two tigers every two years.

We modeled the more realistic scenario of 5 or 3 tigers being introduced in initial phase and supplemented with tigers at varying interval. The survivorship and inbreeding coefficient (Fig. 4 a, b & c) of initial population of 5 and 3 tigers which is supplemented with 2 tigers every 3 or 2 years is good and both have extinction probability less than 6 percent. The supplementation is most important to maintain the genetic vigour and can reduce the risk of extinction. The tiger population of 5 without supplementation has shown high rate of extinction (25%). This reintroduction scenario operates in a situation of very low or no poaching and no prey depletion and thus highlights the importance of either supplementing the introduced population or establishing dispersal corridors with Sariska. Given the insular nature of Sariska Tiger Reserve, the second option is far more formidable and the only option for a viable tiger population in a highly managed tiger population.

---

**Biotic interference in Sariska National Park**

**People on way for  
tree lopping**



**Fuel wood  
collection**

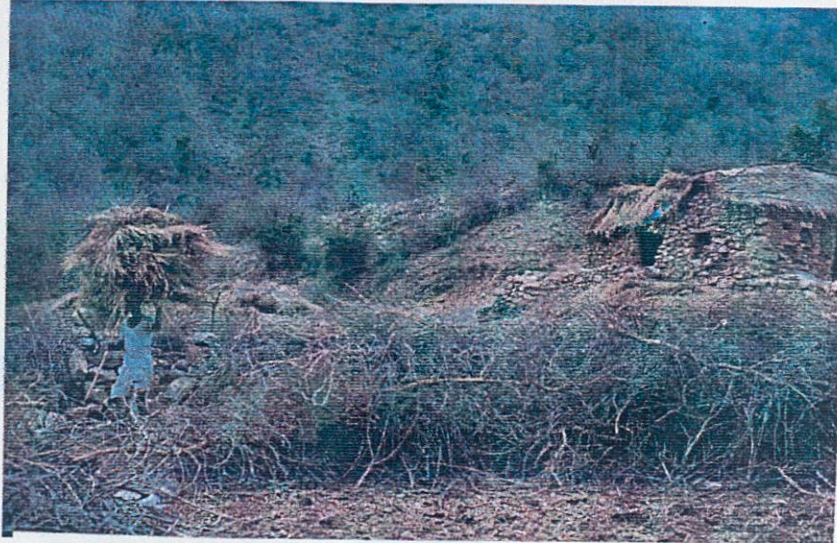


**Livestock grazing**

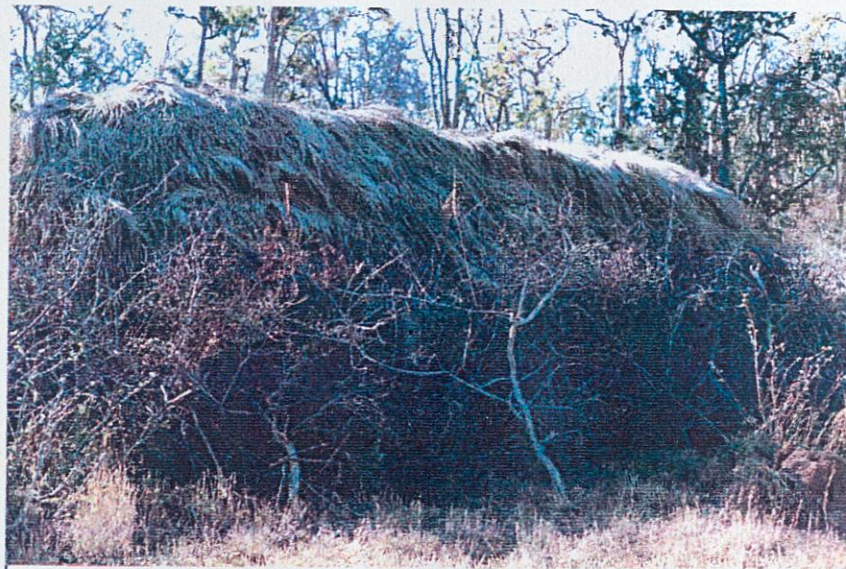


Biotic interference in Sariska National Park

Grass collection



Grass stocking



Lopped trees



Male leopard photographed through Camera Trap

